Planetarium Notes

ADLER PLANETARIUM

**900 E. Achsah Bond Drive, Chicago 5, Ill.
Wabash 1428**

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

August: RAINBOWS AND HALOS. The northern lights, complex halos, and rainbows will be shown. Their causes and the color of the sky and of the setting sun will be explained.

September: THE MOON.

BUHL PLANETARIUM

**Federal and West Ohio Sts., Pittsburgh 12, Pa.
Fairfax 4300**

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

August: THE END OF THE WORLD. This fantasy of the future presents the various ways in which the world might some day end, as indicated by present scientific knowledge.

September: COLORS IN THE SKY.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

August: ROMANCE OF SUMMER SKIES. The constellations and their stories form the material of the August demonstration. Pictures of classical persons and creatures will be shown with their associated star groups.

September: REASONS FOR THE SEASONS.

GRIFFITH PLANETARIUM

P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

August: LEARNING THE CONSTELLATIONS. Twice a year the planetarium stresses the learning of stars and constellations by name. The classical outlines are used and old stories are told.

September: THE MOON.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

August: TRIP TO THE MOON. This always exciting extravaganza will be offered with new thrills that should interest everyone.

September: THE 200-INCH TELESCOPE.

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

Two Novae and a Supernova

EARLY IN JUNE one new star was discovered and another reported, these novae both located in our own galaxy. Early in July a supernova was discovered in exterior galaxy NGC 6946, by Dr. N. U. Mayall, of Lick Observatory, presumably on a plate taken with the 36-inch Crossley reflector. The magnitude of the star was 15.3, its spectrum suggesting that it was a Type II supernova several weeks past maximum brightness.

On June 3rd, Dr. Balfour S. Whitney, of the University of Oklahoma, telephoned the Harvard clearinghouse to report a suspected nova in Cygnus, at 10th magnitude — four plates taken on June 2nd and three on June 3rd showed the new star. It was fainter than magnitude 13.5 on May 2nd, and was not visible on 77 plates taken at Oklahoma during the past four or five years. Observations with the 16-inch Metcalf refractor at Harvard's Oak Ridge station on June 4th gave an estimated magnitude of 8.6. A 1944 plate with the same instrument yielded a provisional magnitude of 17 for the star. The nova's position (1855) is $19^h 47^m.3$, $+36° 11'$. A slit spectrum taken on June 13th at Yerkes Observatory, by

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VOLUME VII, NO. 10
WHOLE NUMBER 82

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AUGUST, 1948

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $3.00 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.50; all other foreign countries, $4.00. Make checks and money orders payable to Sky Publishing Corporation. Canadian and foreign remittances should be made in United States currency. Circulation manager: Betty G. Dodd.

All notices of change of address must be sent three weeks in advance and accompanied by both old and new address, or we cannot make the proper change. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. For most efficient handling of your subscription, please return our bill form with your renewal payment.

Editorial and advertising offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited manuscripts unless return postage is provided by the author.

Guiding Small Telescopes

By Robert Fleischer, *Rensselaer Polytechnic Institute*

IT IS A MATTER of common experience in photography that during a time exposure, or even an ordinary snapshot, both the subject and the photographer holding the camera must be motionless. If either is not, then the resulting photograph consists of a succession of images — in astronomical parlance, the picture is trailed. In landscape photography, or in still-life studies, this problem is taken care of by mounting the camera firmly. In sports photography, bright lighting and short exposures are used, so that the motion can be "stopped."

The objects we want to photograph in astronomy, the stars, are in apparent motion. Yet even with the fastest cameras and films at our disposal, we must use time exposures, since the stars are so faint. These exposures are exceedingly long compared to those in conventional photography, five minutes being generally considered a short exposure, with the average perhaps a full hour. Since we cannot make the stars stand still, we must move the camera to follow their apparent movements, the most evident of which is the stars' diurnal motion: they rise and set. Following this motion is a problem for any telescope, photographic or visual. It is usually done by means of a firm equatorial mounting and a clock drive of some kind; sometimes, for smaller instruments, the following is done by hand.

In all cases where a celestial object is to be viewed for more than a few minutes, an equatorial mounting is preferred to any other. For photographic purposes we shall consider it a necessity, and we shall prefer that an automatic drive clock be attached, the more accurate in rate, the better.

If the only apparent motion of a star were that due to the earth's rotation, it might be possible to build a telescope mounting and drive which would follow the stars as perfectly as desired. Unfortunately, there are other motions superimposed on the daily rising and setting. None of them is large enough to interfere seriously with visual observing, but most are of importance when it comes to photography. I shall merely list them, as in practice they do not often need to be distinguished.

One such motion is due to refraction, which lifts the stars up from the horizon by varying amounts depending on each star's apparent altitude. Another is seeing, or twinkling, which makes the stars appear to dance back and forth across the field of view of a telescope. Since we do not ever have truly perfect equipment, we must consider also errors in the adjustment of the equatorial mounting, and errors in the driving clock. Vibration of the telescope due to wind is often a serious problem. Naturally, the better the mounting is, the less trouble will arise from these last two causes, and it is worthwhile to devote attention to building a good mount. But many professionally used telescopes shake in the wind, and have their power transmitted in noticeable pulses from the driving clock. These difficulties are usually only remedied by building new equipment, and the good observer should be able to control his present instrument and obtain satisfactory results.

The Principle of Guiding

Since no automatic mechanism for following the irregular motions has come into general use the observer himself must take its place (but see *Sky and Telescope,* March, 1948, page 119). The process is in many respects analogous to driving an automobile. On a straight level road the car would probably stay in its lane without guiding, but the driver is ready to supply slight corrections as they are needed. On curved mountain roads, continual manipulation of the steering wheel is needed. This corresponds astronomically to nights of bad seeing.

In driving, one often judges the position of the vehicle by sighting across the radiator ornament to the edge of the road. In guiding a telescope, an observer keeps it adjusted so that the crosshairs continuously intersect upon the image of a star, called the guide star. The crosshairs are rigidly fixed with respect to the plateholder. They may be at the focal plane of an auxiliary instrument, the finder or guiding telescope, which itself is attached rigidly to the tube of the photographic telescope (Fig. 1). Or, the crosshairs may be mounted in the focal plane of the photographic objective itself, in which case the guide star cannot be the star which is photographed (Fig. 2). In either event, the crosshairs are examined with an eyepiece, which should be of the same power as the optical aid that will be used to examine the final photograph. A 1-inch eyepiece, magnifying 10 times, is ordinarily used. The crosshairs must be illuminated in some way so that they will be visible against the dark sky.

The observer looks in the guiding eyepiece either continuously or at frequent intervals. When necessary, he moves the telescope by means of mechanical or electrical slow motions so that the star image always remains at the

Fig. 1. The 3-inch Ross camera of Rensselaer Observatory. The guiding telescope, of focal length equal to that of the camera, is separate from the main tube. Notice the flexible cable extension to the slow-motion knob. The observer's left hand is adjusting the conveniently placed rheostat to control the illumination of the field of view. The bulb and small mirror are in the small housing on the side of the finder, halfway up the tube. This telescope was provided by the committee on research activities of Rensselaer Polytechnic Institute.

intersection of the crosswires. The frequency of checking depends on the wind and the seeing, on the position of the telescope, and on the perfection of the mount. It can only be determined by experience. One cannot *look* into the eyepiece too often; perseverance pays off high dividends here. Excellent plates have been made in windy weather with poor mountings and no clockwork by observers who sat with their eyes to the eyepiece and continuously operated the slow motions. On cold nights in winter this is no mean feat, but the satisfaction of pulling a perfect plate out of the hypo bath is worth the effort.

The Guide Telescope and Crosswires

If the focal length of the objective forming the image of the guide star is greater than that of the objective forming the photographic images, the apparent motions of the guide star will be greater than the motions of the stars on the plate. This is an evident advantage, for it will then be easier to detect the deviations leading to trailed images. If the guiding telescope has the shorter focal length, a higher power eyepiece may be used to magnify the motions of the guide star; however, this is not a complete substitute. When the guiding is done on a star in the focal plane of the photographic objective, as in the arrangement shown in Fig. 2, the focal lengths are, of course, equal. This is usually the case also when an auxiliary guiding telescope is used. In order to make use of fainter stars, and to reduce the size of the diffraction patterns, it is generally recommended that the guide telescope objective have at least half the diameter of the photographic objective, but for much work a smaller ratio will be found adequate.

The crosswires used must be very thin, so that the apparent star disk can be bisected by them. Various devices are used. Reticles may be purchased, or fine lines ruled on glass may be made with a diamond-point glass cutter. Fine glass strands may be made from hot glass tubing by exactly the technique used in pulling taffy. Finely drawn metal wire for crosshairs may be purchased from some engineering instrument houses. The cheapest crosshairs are obtained from spiders, and these are also the most satisfactory in many respects. It is necessary to collect the spider web when it is fresh, but it may be stored for years.

Certain spiders, when dislodged from their webs, spin out a line as they fall, to use in climbing up again. Henry Sawyer, veteran observer at Harvard (see front cover), uses a wooden reel and catches the line above the falling spider. He then winds up the reel as fast as the spider falls. Eventually the spider gives up and drops to the ground, but before this happens enough crosshair material to last several years has

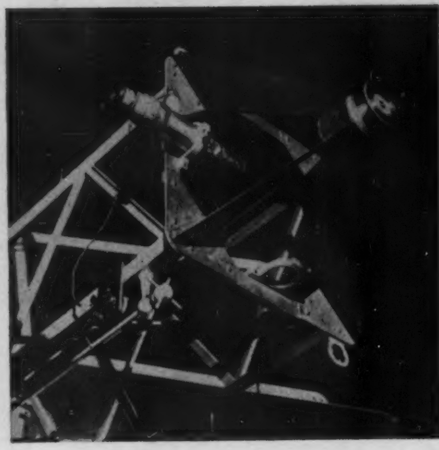


Fig. 2. The upper end of the tube and the prime focus of Rensselaer's 12-inch Rasmussen reflector. The small tube at the left holds a 45-degree prism, an illuminating lamp, crosshairs, and an eyepiece. With this arrangement the guide star is in the same focal plane as the photographic plate, but does not appear on the plate. There is no separate guiding telescope. The plate is placed at the prime focus, in the circular plateholder which is seen in the upper right.

been wound on the reel. It is stored in a box to keep out dust. When crosshairs are needed, a length of web is transferred on a U-shaped wire to the ring which will hold it in the focal plane, and it is fastened in place with drops of shellac or glue. If spiders are not available, as in the wintertime, fibers can be picked out of silk thread, to make an acceptable substitute for the spider web. All crosshairs in use should be free of dust and loose strands, which tend to brighten the field of view and confuse the observer.

Whatever the type of crosshairs used, the illumination may be provided from the side, or else by light shining into the eye of the observer from beyond the crosshairs. The former arrangement produces bright lines on a dark field, while the latter gives a faintly illuminated field against which the crosshairs appear black. In this second method, the light is reflected into the field by a very small 45-degree mirror somewhere in the telescope tube. This is much simpler to construct and adjust than the side illumination, but it does mean that not so faint guide stars can be used as with the dark field. In either case, the lamp providing the light should have a rheostat so that the brightness of the light can be adjusted to the proper intensity.

Parallax

One frequent cause of poor guiding is that the plane of the crosshairs is not coincident with the focal plane of the telescope. Then the relative position of the star and the crosswires depends on the position from which the eye looks into the eyepiece, and this is never the same twice. Hence, the star will usually appear off the intersection even when the telescope has been following perfectly, and the attempt to bring it back will result in a photographic image like the one shown in Fig. 4.

The remedy for this is to form the habit of frequently checking (between exposures) against parallax by moving the eye back and forth across the line of sight while a star is on the intersection, and adjusting the crosshairs so that the star image does not move when the eye does. Whether to rack the crosswires in or out of the tube may be determined by trial and error, but it is better to figure it out. The object which moves with your eye is the most distant, as you can see by analogy with the shift between your hand and a distant object as you move your head.

So that the crosshairs may be seen in front of the star image, pick the brightest possible guide star. But never throw the telescope out of focus to produce a large image upon which to guide, for parallax will be introduced.

Guiding Technique

If from experience you know that your mounting is good, and that it always takes a certain period of time for the guide star to depart perceptibly from the crosswires, then it is quite possible to get good plates by guiding only intermittently, perhaps every five minutes or so. This practice will be successful, however, principally on quiet nights of no wind and good seeing. On the other hand, many of the short-focus cameras of Harvard Observatory, the patrol cameras, are never guided, and exposures of one hour are quite successful. The longer the focal length, the greater the necessity for continuous guiding.

When it is very windy, so that the principal motion of the guide star re-

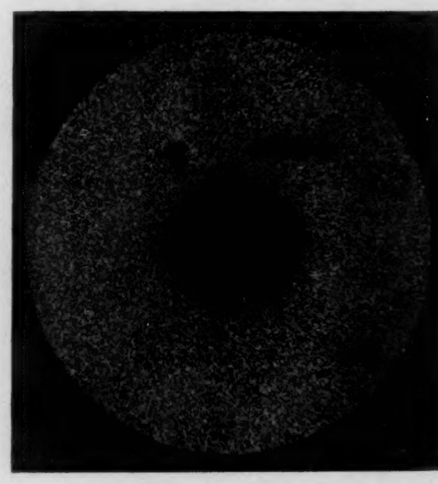


Fig. 3. Unguided star image. This and Figs. 4 and 5 are 25x enlargements of negatives made with the camera in Fig. 1. The instrument was not guided for this image, which is trailed due to an error in the worm.

sults from the shaking of the telescope, it will often be true for small telescopes that the slow motions cannot be operated rapidly enough, to counteract the oscillations. In this case, it may pay to guide by pushing on the telescope directly by hand.

Many telescopes have very firm mountings and accurate clocks, but suffer from a defect in the worm which drives the polar axis, so that once or twice during each revolution of this worm the guide star performs an oscillation with respect to the crosswires. This is very annoying, since it precludes the possibility of taking unguided plates with a mounting which would otherwise permit it. But this may be a blessing in disguise, for it makes guiding imperative at regular intervals (the period of the worm), and thus insures that the practice of intermittent guiding does not degenerate into no guiding at all.

Overguiding

It may seem too obvious, but it must be mentioned for what follows, that there are two ways to set a star upon the intersection of the crosswires. One is to move the star to the intersection slowly and to stop when it gets there. The other is to give a moderately strong turn to the slow-motion screw so the star overshoots the mark, and then, having noticed the amount of overshoot, to bring the star back. This second method is one which many are tempted to use, because it is employed in familiar instances of setting pointers on marks — in tuning a radio, for example. But in astronomical guiding, it is bound to result in poor plates. *Always move the slow motion less than you think you need to.* You can move it again, if necessary, but if you move it too far you merely place the star in one more position on the plate, and help produce a spoiled image.

When you look in the guiding eyepiece and find the star away from the intersection, you want to get it back on the crosshairs as quickly as you can, without moving it all around the field and extending the image. This means that you must memorize in advance which slow motion (right ascension or declination) must be moved and *which direction to move it,* for the different quarters of the field. So when you start guiding, before opening the shutter, turn the slow motions and notice carefully the motion transmitted to the guide star in the field of view. This will avoid much grief in the form of irregular, trailed images.

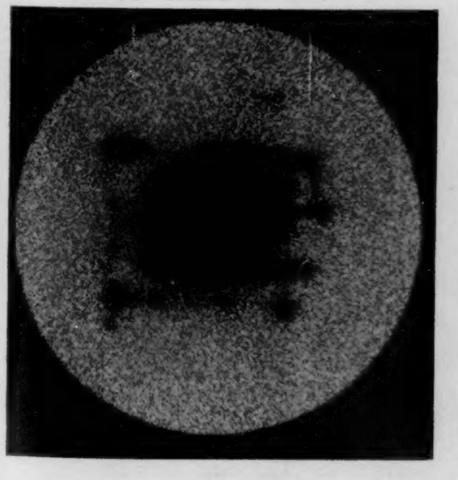


Fig. 4. Overguided star image. Here the star was shifted too frequently and in the wrong directions, and the guiding telescope had not been checked for parallax.

One more word on overguiding. I have emphasized that it is well to check on the guide star frequently. At the same time, you should not move the slow motions unless it is necessary, nor without knowing which direction to move them. The smoothest automobile driver is one who does not weave back and forth without reason, although he is ready to turn the wheel the right way at any instant. A common mistake in guiding is to feel that the slow motions must be moved every few seconds. This is not true. Only when the guide star has clearly departed from the intersection should the proper slow motion be moved promptly.

Often, when using a faint guide star in a bright field, one may look into the field and not see the star at all, generally because it is hidden behind the crosshairs. Then there is a strong temptation to move the slow motion until the star comes out where it is visible, and then to move it back. This gives the observer renewed confidence, because he now knows where the star is. It also trails the plate!

To avoid this problem, one should always choose the brightest possible guide star which will cause the desired region of the sky to fall centrally on the plate. This star will frequently be somewhat away from the region, as when photographing nebulae. A few minutes spent in studying star charts to pick the best possible star for each exposure will greatly increase the number of good plates. Also, using a star chart for this purpose takes less time than it does to hunt for a good guide star with the telescope, and it can be done beforehand and indoors. (In fact, it is true of all the steps in observing that prior planning in great detail is a help — all the steps and information needed to take the plates should be written out as an "observing program" which the cold and sleepy observer can refer to in lieu of his memory.)

To evaluate the effects of overguiding, compare Figs. 3, 4, and 5. Fig. 3 shows two unguided images, one of a bright star, and one a faint star. They are slightly trailed, due to a worm defect as described above. Fig. 4 is an image made by a beginner who over-

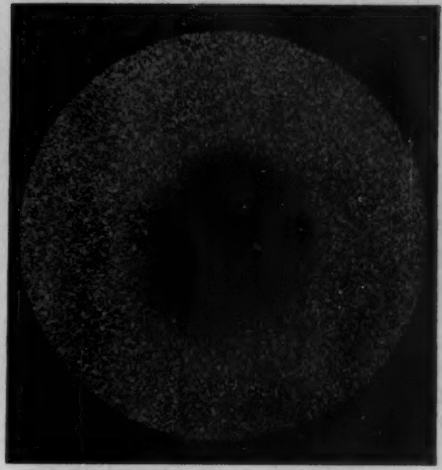


Fig. 5. Correctly guided image. The asymmetry is from optical aberrations, since the image is far off axis. Here the guide star was kept in place, but not moved more frequently than necessary.

guided, violating all the rules we have mentioned. The images in Figs. 3 and 4 are at equal distances from the plate center, and are of stars at the same declination. While the unguided images of Fig. 3 are not round, and would be hard to measure, they are evidently better in all respects than the image in Fig. 4, which would be impossible to measure. The beginner obviously would have obtained a better plate if he had not guided at all.

By way of contrast, Fig. 5 shows an image from a well-guided plate, again the same distance from the optical axis as the others. This image (of a brighter star) is not perfectly round either, but this is not due to guiding error. At that distance from the optical axis of the lens, aberrations became evident. The other images would have displayed aberrations too, if they had been stationary during the exposure.

Polar Adjustment

An equatorial mounting adjusted for visual work will often not be pointed to the pole with sufficient accuracy for photographic work, and this will make guiding extremely difficult. The effect of the maladjustment is to cause the guide star to move continuously away from its position, the motion being in both right ascension and declination.

Detailed instructions along with the theory of the polar adjustment are given in King's *Manual of Celestial Photography* (Eastern Science Supply Company, 1931), and will merely be summarized here. The aim is to have the polar axis of the telescope point to the refracted pole, and not to the altitude which is equal to the latitude of the station. The adjustment may be made with surprising accuracy by the method to be described.

Start with the axis in the best adjustment which can be obtained by simple means (see *Making Your Own*

Telescope, Chapter XII, Sky Publishing Corporation, 1947). If possible, the mounting should be equipped with adjusting screws which can move the polar axis in altitude and in azimuth. Where this is not the case, the leveling screws can be used, but the process will take several more trials. The first step is to set the crosshairs on Polaris, and let the telescope drive for five minutes. If the star has then moved from the intersection *parallel to the ground,* the polar axis must be changed in *elevation.* Conversely, if the star has moved perpendicular to the ground, the azimuth of the polar axis is out of adjustment. The direction in which to make the change can best be determined by trial and error.

After removing the effects which can be seen visually in five minutes of driving, tests can be made photographically. Point the telescope to the pole. Start an exposure by letting the stars trail over the plate for about four minutes. Then turn the drive on for 15 minutes. Mark the plate so that after development you can place it in the same position (with respect to the ground) it had during the exposure. Then it will be possible to tell how the stars moved, up, down, east, or west, while the drive was running. For the trails made while the telescope was stationary will be arcs of circles having a common center on the plate, and these mark the beginnings of the trails made while the drive was running. These latter trails will all be parallel. The adjustment for altitude or azimuth is indicated just as in the visual case.

At this stage, measure the length of the trails made while driving, and record the amount the adjusting screw is turned before the next exposure is made. This second exposure is made and measured in exactly the same way as the first. From the difference in trail lengths, the effect of a known turn of the adjusting screw is found, and the remaining correction can be computed. It is wise to correct for only one coordinate, altitude or azimuth, at a time.

After the 15-minute exposures with the clock driving produce round images, exactly the same procedure is extended to 3-hour exposures. Here the corrections are only 1/12 as large as before for the same length trails. Since they are known from the 15-minute plates, only one or two 3-hour plates should be needed to set the telescope in perfect adjustment. Notice that no guiding is possible or necessary for these pole exposures.

When the leveling screws (or shims) are used to make the adjustments, the altitude of the polar axis can, of course, be changed by raising or lowering the north end of the base. The azimuth of the axis can be moved westward by raising the east side of the base. This will also change the altitude somewhat, and the north end might need to be raised after the azimuth adjustment. Adjustment by the leveling screws, which would not be successful in low latitudes, proceeds by a series of approximations, and it cannot be used to move the axis through several degrees in azimuth without unbalancing the telescope.

The procedure of polar adjustment described here will take at least two evenings at the beginning of the telescope's career, but the time is well spent, because without it one would have to guide continuously in both right ascension and declination. With the polar axis in adjustment, the labor of guiding is considerably reduced. From time to time, every six months or every spring, it is well to take a 3-hour polar adjustment plate, at least until a new pier has completed its settling. If a record is kept of the changes made in the initial adjustment, it will be possible to readjust the axis quickly if any shift has taken place.

Special Guiding Problems

For some work, the guiding technique

(Continued on page 249)

NEWS NOTES

By Dorrit Hoffleit

THE HALE TELESCOPE

The long-awaited event of the dedication of the 200-inch telescope is now a matter of history. On June 3rd, in the presence of Mrs. Hale and 800 invited scientists and other visitors, the "big eye" was appropriately christened the Hale telescope in honor of George Ellery Hale. Not only was Dr. Hale the inspiring genius who envisioned the 200-inch project some 20 years ago, but he was also the founder of two other largest-telescope observatories: Yerkes Observatory with the largest refractor, and Mount Wilson Observatory with its 100-inch reflector.

At the dedication an address entitled, "The Challenge of Knowledge," was given by Dr. Raymond B. Fosdick, president of the Rockefeller Foundation. He discussed gravely the increasing lag between advancing knowledge and social control, but pointed out the impossibility of fixing boundaries beyond which intellectual adventure shall not be allowed to go, stating, "The search for truth is, as it always has been, the noblest expression of the human spirit." His closing words were:

"We need in this sick world the perspective of the astronomer. We need the detachment, the objectivity, the sense of proportion which this great instrument can bring to mankind. This telescope is the lengthened shadow of man at his best. It is man on tiptoe, reaching for relevancy and meaning, tracing with eager finger the outlines of order and law by which his little life is everywhere surrounded. There is nothing which so glorifies the human race, or lends it such dignity and nobility as the gallant and inextinguishable urge to bring this vast, illimitable complexity within the range of human understanding. In the last analysis, the mind which encompasses the universe is more marvelous than the universe which encompasses the mind....

"So we dedicate this instrument today in humbleness of spirit, but in the firm belief that among all the activities and aspirations of man there is no higher peak than this. There is a real sense in which Mount Palomar is Mount Everest."

VARIABLE STAR PROJECT COMPLETED

At a meeting of the American Philosophical Society recently, Dr. Cecilia Payne-Gaposchkin, of Harvard Observatory, reported on a project started some nine years ago and supported largely by the Milton funds of Harvard University. This was the determination of accurate light curves of the 1,500 brightest variable stars, including some 400 of long period, 400 semiregular, 400 eclipsing, 150 Cepheids, and 50 cluster-type variables.

The data now obtained for these stars will permit a study of their physical properties, both as individuals and as members of the general stellar population. This, in turn, will lead to further investigation of the physical differences among stars of the same class situated in very different parts of the galactic system.

SHORT WAVE AFFECTED BY THE MOON

Radio engineers have noted that three or four days after new or full moon the usable bands of frequencies for short-wave broadcasts to distant stations are slightly narrower than at other times. This effect has been associated with the tide-producing action of the moon on the ionospheric layers of the earth's atmosphere. Recently Dr. A. G. McNish, of the National Bureau of Standards, pointed out that tides in the atmosphere alone do not account for the variations observed. The sun first plays its role by ionizing the atmosphere on the earth's sunlit side. Currents flow in this ionized atmosphere, and are modified by the tidal effects of the moon. This tends to lessen the ion density, thereby reducing the highest frequency that can be used for broadcasts.

Astronomical League Convenes at Milwaukee

By Margaret Back, *Detroit Astronomical Society*

IF YOU MISSED OUT at Milwaukee over the July 4th weekend on the eager, friendly reunion of men, women, and juniors associated with the Astronomical League, promise yourself right now to attend the next annual convention. This year's preparations made in advance by the Milwaukee convention committee, the convenience of having meeting, dining, and sleeping rooms in Concordia College, the beauty of the Wisconsin scenery and of Yerkes Observatory, all filled us with joy at having made the pilgrimage.

In all, there were 190 registrants, representing 20 states and the District of Columbia. Wisconsin had the highest attendance with 63 members and friends; then came Illinois, 29; Michigan, 25; Indiana, 11; Minnesota, 9; Massachusetts, New Jersey, and Washington, D. C., 7 each; Pennsylvania, 6; New York, 5; Ohio, 5; Kentucky, 4; Oregon, 3; Maryland, 2; and Connecticut, Florida, Iowa, Mississippi, Missouri, Tennessee, and Virginia, 1 each.

To add greatly to our convenience, early arrivals were welcomed and registered Friday evening, July 2nd. And the national council of the league was hard at work at an 8 o'clock breakfast on Saturday morning.

Howard Thomson, Milwaukee weatherman, being a member of the Milwaukee Astronomical Society, saw to it that the sun greeted us all the time. The two field trips were unspoiled by weather, although during our visit to Yerkes Observatory on Sunday evening, clouds crept up for about an hour, but then cleared off entirely to give good visibility when D. L. Harris, of the observatory staff, trained the 40-inch refractor on the quadruple star, Epsilon Lyrae.

On arrival at Yerkes, with its three beautiful domes and marble halls, we were given a cordial welcome by Dr. George Van Biesbroeck. Mr. Harris delivered a most informative talk on "Recent Planetary Investigations," outlining the program of work being carried on at McDonald Observatory with the large spectrograph and lead-sulfide cell. The spectrometer was described and some of the recent results were discussed. It was during this research program that Dr. Gerard P. Kuiper made the exciting discovery of the fifth satellite of Uranus. For many amateurs, this first visit to historic Yerkes Observatory, the tri-domed structure in its lovely setting above Lake Geneva with the glittering night lights and Fourth of July flares outside, was memorable.

Our first convention evening was spent at the extensive site of the Milwaukee Astronomical Society Observatory. It is not surprising that this society stresses telescopes and definite observing programs, as the observatory caters to members' observing convenience, their slumber, and their meals! There is a large collection of astronomical literature of all kinds. A 13-inch reflector and two smaller telescopes, as well as radio and photographic apparatus, are housed at the observatory.

As the reader now has some idea of the happenings in the glories of outdoor Wisconsin, let us look inside Concordia College on Saturday morning, July 3rd, at 10 o'clock, when the opening session was held in the library building. Edward A. Halbach, president of the Astronomical League, called the meeting to order. President L. C. Rincker, of Concordia College, through whose generosity this headquarters was placed at our disposal, addressed a few words to the gathering. He termed astronomers "a fine group of explorers not out for any personal gain."

Herbert W. Cornell, assistant secretary of the host society, described the "Guide to the Use of Star Maps," a copy of which was presented to each person on registration. Prepared for use in connection with the set of University of Toronto star maps, this is an outline of general observing hints, lists of constellations and star names, and a detailed discussion of various constellations and objects visible through the different months of the year. The Milwaukee Astronomical Society also has published a summary of planetary phenomena for the years 1948 and 1949.

Roll call and reports of member societies followed. This is an ever-popular and interesting feature of the league conventions, in which one representative of each member organization gives the number of delegates present and adds a short report of the society's activities. In this manner, all groups take part, and each enjoys a resume of the experiences and activities reported by others.

After luncheon, there was a session for members' papers, at which Charles Strull, of Louisville, Ky., acted as chairman. "Popularizing Astronomy" was the title of the talk by Carl H. Gamble, who described the manner in which the Popular Astronomy Club, of Moline, Ill., has grown in numbers and enthusiasm. R. S. Young, also of Moline, concentrated on advice regarding the "Organization of Amateur Societies."

Two papers by junior members of the National Capital Astronomers, of Washington, D. C., were read. "An Amateur Observes the Planets" was prepared by John Lankford, and the "History of Variable Stars," by Leo M. Carroll.

J. T. Wilson, physicist at the Allis-Chalmers Co. in Milwaukee, was the principal speaker of the afternoon, discussing "Recent Investigations of the Sun's Radiation." He showed solar films made at the High Altitude Observatory in Climax, Colo.

On Sunday morning, with C. H. LeRoy, chairman of the Middle East region, presiding, a varied feast of subjects was presented to suit the tastes of all. Amateur telescope making, the construction and operation of radar equipment for observing meteors, and the different functions of the sun, were topics prepared for presentation respectively by August Wendt, Moline, Ill.; Charles A. Little, Washington, D. C.; and A. Forest Steepleton, Chicago, Ill. President Halbach spoke informally on the annular eclipse of May 8-9, and outlined the geodetic problems which the elaborate expeditions of the National Geographic Society hoped to help solve. Mr. Halbach had just recently returned from Burma, where he had led one of the Geographic's observing parties.

At the close of the morning session, everyone gathered in the humid sunshine for the group photograph (see page 252), and amateur cameramen had themselves a busy time. Pictures were also taken of the many telescopes, devices, photographs, and models on display in the dining hall, where everyone had ample opportunity to inspect them throughout the three days of the meeting. One of the most interesting exhibits was a model in cardboard of the 200-inch telescope, constructed by S. E. Hubbard. The model could be moved in right ascension and declination.

The banquet Sunday noon was climaxed with a newsy description of Charles A. Federer's motor trip with his family from Cambridge, Mass., to the West Coast to attend the joint meeting of the American Astronomical Society and the Astronomical Society of the Pacific. He spoke of visits to the High Altitude, Lowell, and Lick observato-

ries, and to Meteor Crater, and described the impressive gathering of 400 persons at Pasadena who pilgrimaged there and to Mount Wilson and Palomar Mountain for the sessions. At Mount Wilson an excellent documentary film of the 200-inch telescope, in color and sound, had been shown, and that evening the 100-inch telescope was devoted to the observation of Saturn by one and all, young and old.

Section meetings which ran in staggered arrangement were held on Sunday afternoon, on instruments, observing, and programs for meetings. These smaller discussion groups, keynoted by short talks, led as usual to many helpful hints and the exchange of ideas among the amateurs present.

On Monday morning, L. E. Peterson, of Milwaukee, gave the story of two trips he took to South America in 1946 and 1948, when he visited observatories in Bogota, Colombia; Quito, Equador; and Rio de Janeiro, Brazil. Interesting kodachrome pictures were shown.

A business session concluded the official part of this most worthwhile and enjoyable convention. National officers for the term beginning September 1, 1948, were elected as follows: Mrs. Helen S. Federer, Cambridge, Mass., president; William C. Oberem, Buffalo, N. Y., vice-president; Mrs. Margaret Back, Detroit, Mich., secretary, re-elected; Carl P. Richards, Salem, Ore., treasurer, re-elected. Mr. Halbach announced action at the national council meetings as follows: approval of new memberships in the past year; tentative approval of the boundaries of the four regions now established, subject to boundary revision; establishment of a committee to consider an insignia for the Astronomical League; authorization of the formation of a Latin-American region, to extend southward from the southern boundaries of the United States in the Western Hemisphere; the selection by lot of the initial terms of office of national council members as follows: Northwest and Middle East regions, three years each; Northeast region, two years; North Central region, one year.

General discussion of coming convention plans left open the choice of a place for next year. An invitation from the Darling Astronomy Club to meet in 1954 in Duluth, near which there will be a total solar eclipse on June 30th, was received with enthusiasm for future consideration. A convention on the West Coast at some future date was also discussed.

And so the Astronomical League grows and rolls onward, with four regions organized in the United States, with 46 member organizations including those in Buenos Aires and in Aruba of the Netherlands West Indies, and with many national and regional conventions behind us and to come.

Amateur Astronomers

New York Amateurs Visit Nation's Capital

FIFTY members and friends of the Amateur Astronomers Association of New York took part in the Memorial Day weekend field trip. By special car on the Pennsylvania Railroad, we arrived in Washington, D. C., at 12:30 on Saturday afternoon, May 29th. Various groups scattered on sightseeing projects. One contingent was invited by Grote Reber, of the National Bureau of Standards and vice-president of the National Capital Astronomers, to visit the field laboratory in nearby Sterling, Va. There two 30-foot aluminum-grid parabolic reflectors, equatorially mounted and clock driven, make continuous recordings of radio energy from the sun. We were also afforded an opportunity to glimpse microwave apparatus and other experimental equipment of the Bureau of Standards.

Our dinner at the hotel was taken with members of the Washington society, and then some of us worked in a quick dash to Charles Little's home laboratory, where he has successfully developed a radar pulse and oscillograph-recording device for the detection of meteors. This instrument is believed to be one of very few of its kind in the country.

That evening we visited the Naval Observatory, where U. Sherman Lyons and Morgan Cilley, aided by Mr. Reuning, also of the Naval Observatory staff, generously acted as guides. We were shown the time service, the library which contains the finest collection of astronomical books in the country, a photoheliograph with a record of the day's sunspots, and two large telescopes, the 26-inch refractor and the 40-inch reflector. There is also a 12-inch refractor on the main building, and out on the grounds in a small separate building is the NCA's own 5-inch telescope, which may be used at any time by a selected list of competent members of that organization.

On Sunday morning, everyone followed his own dictates. A small group visited the unique private observatory of David Rotbart, a member of the NCA and co-discoverer of a comet in 1946. The lavishness and ingenuity of his equipment was viewed with wide-eyed admiration. His backyard observatory is octagonal, eight feet in diameter, with an eight-sided roof which revolves easily by hand. In the restricted space around his clock-driven telescope he has an efficient arrangement of charts and photographs, a globe, clocks, and gadgets. In the yard is mounted a huge pair of Japanese binoculars with 6-inch objectives. A second telescope can be seen on an iron balcony outside a room on the top floor of Mr. Rotbart's house; the room is an auxiliary observatory and workshop with added equipment of every description.

The National Museum and the National Gallery of Art were visited preceding an evening at the Georgetown Observatory, where even a heavy downpour of rain could not spoil the radiant hospitality of our hosts, led by Father F. J. Heyden, who has recently returned from the annular eclipse expedition to China. Monday was occupied sightseeing, including the Smithsonian Institution. At 6 p.m., 50 weary but indomitable amateurs met at Union Station. In the midst of surging holiday crowds, the luxury of our own car was again heartily appreciated, and everyone relaxed in the contentment of a highly successful weekend.

CHARLOTTE MALSBARY
Amateur Astronomers Association
New York City

METEORITICAL SOCIETY

The 11th meeting of the Meteoritical Society will be held in Albuquerque, at the Institute of Meteoritics, University of New Mexico, on September 7th and 8th. A lecture on archeological discoveries in New Mexico is to be given, and a field trip in the Sandia Mountains is planned. Anyone interested is invited to attend the meeting. Further information may be had from Dr. Lincoln La Paz, University of New Mexico.

SACRAMENTO EXHIBIT

At the California State Fair running from September 2nd to 12th, the Sacramento Valley Astronomical Society will again have an astronomical display, with an exhibit space about 10 by 30 feet. Sunspots will be projected daily, and during the evening outdoor observations will be conducted, using a 10-inch reflector.

The fair exhibits committee of the SVAS is composed of Carl Fogus and H. Simmonds.

THIS MONTH'S MEETINGS

Chicago: The Burnham Astronomical Society will hold its annual observation party and barbeque on Saturday, August 14th, at the home of Mr. and Mrs. H. C. Torreyson, Prospect Heights, Mount Prospect, Ill. All members who have telescopes are urged to bring them to this meeting.

Indianapolis: Meeting at Link Observatory on August 1st, the Indiana Astronomical Society will hear a lecture on "Star Colors" by Walter Wilkins.

Kalamazoo: "Progress on Palomar" is the subject of the talk to be given by James Sigler at the August 14th meeting of the Kalamazoo Amateur Astronomical Association, at the home of Mr. and Mrs. Spencer Van Valkenburg, 125 W. Washington St., Vicksburg, Mich.

Los Angeles: On Tuesday, August 10th at 7:45 p.m., the Los Angeles Astronomical Society will meet at the Griffith Observatory. Dr. H. P. Robertson, California Institute of Technology, will discuss the question, "Is Space Really Curved?"

TERMINOLOGY TALKS -- J. Hugh Pruett

Elliptical, Parabolic, and Hyperbolic Velocities

Various methods, more or less accurate, have been worked out for determining the heliocentric velocities of meteors as they enter our atmosphere. If the value is found to be less than the limiting velocity of 26.2 miles a second, it is inferred that the meteor in question is a regular member of the solar system and has been traveling around the sun on an ellipse — it has an *elliptical velocity.*

The other two types of possible orbits, the parabola and the hyperbola, are not closed curves. A body traveling on one of these is not a permanent member of the solar system and may possibly have come from interstellar space. The limiting velocity for a closed orbit is called the ***parabolic velocity;*** any speed which is greater than this is ***hyperbolic.***

All meteors of regular showers have elliptical velocities, although some, such as the Perseids and the Leonids, come near the parabolic value. The extensive visual studies of Hoffmeister of Germany and Opik of Estonia indicate that the majority of sporadic meteors have hyperbolic velocities, thus signifying that they are not regular members of the solar system. However, the photographic work of Whipple, at Harvard, on a much smaller number of meteors fails to show that any have greater than elliptical velocities. Of 49 trails that have been well observed, 32 can be assigned to known showers, nine are sporadic, and eight are questionable. No meteor having a hyperbolic velocity has yet been photographed.

Meteor Terminology

The story is told that when Professors Silliman and Kingsley of Yale reported almost 150 years ago that their investigations of the rumored shower of stones from the sky at Weston, Conn., had convinced them it was not of terrestrial origin, one of the highest ranking officials in the national government remarked, "Gentlemen, rather than think that stones fell from heaven I would believe those Yankee professors would lie." Most scientists at that time had grave doubts as to the celestial origin of meteorites, whereas today we have advanced to the point of determining what names to apply to one of these objects for various stages of its existence.

Thus, while it is flying through space as a dark body before it reaches the earth's atmosphere, where heating takes place, it is often called a *meteoroid.* Then when it flashes into luminosity in the upper air, it becomes a *meteor.* If a part of the body withstands the fiery ordeal and reaches the earth — and is again a dark body — it enters its third state and is a *meteorite.* Should the meteorite be neglected for a long period of time until excessive alteration has taken place, its name may change again — but this time most gradually — to *meteorode.* This last term, however, has been applied only to the ancient fall at Brenham Township, Kans.

Some scientists believe in more simplified nomenclature. Dr. F. C. Leonard, of the University of California, Los Angeles, an authority on meteoritics, says, "I use the one term 'meteorite' to designate the body wherever it may be — in space, in flight through the earth's atmosphere, or on the earth. 'Meteor' then becomes simply the luminous phenomenon of the meteorite's flight through the air." We see only the meteor effect although a meteorite is responsible for the aerial disturbance. This writer favors the Leonard system.

Along this same line, ***meteoritical*** and ***meteoritic*** are adjectives which imply a connection with meteorites or a discussion of meteorites. Meteoritics is the science of meteorites, in which a ***meteoriticist*** is a specialist.

Falls, Finds

A ***fall*** includes all pieces of meteorite that descend as a group at any certain time and place. At times there is only one piece; in other falls, thousands. The number of falls during any year over the world is unknown. A ***find*** is a fall that is recognized as meteoritical and recovered. Throughout historical times in all the world the number of finds is comparatively small. According to the catalogue of Dr. H. H. Nininger, of the American Meteorite Museum, there were about 1,400 authenticated finds on record up to March 1, 1948.

Classes of Meteorites

There are numerous varieties of meteorites, but all are generally grouped into three classes: ***siderites,*** or irons; ***aerolites,*** or stones; and ***siderolites,*** or stony-irons. The siderites are composed principally of iron which is alloyed with smaller amounts of nickel and a few other elements. The aerolites are stony material in which are usually embedded silvery-appearing grains of nickel-iron. The siderolites, rarest of the three classes, are composed more nearly of equal parts of metal and stone. The metal is arranged in a sort of network in which the stony crystals are enclosed. Plane, polished faces of meteorites are quite interesting. When a polished surface of one type of siderite (octahedrite) is etched with suitable chemicals, the beautiful crystalline structure known as Widmanstaetten figures is brought into view. This is distinctly a "writing of the skies" for no terrestrial material, either natural or artificial, is known in which these figures are brought out with anything like the clearness produced in meteorites.

GUIDING SMALL TELESCOPES

(Continued from page 246)

must be modified. For example, if the light from the telescope is to be fed into a slit spectrograph, then a small auxiliary telescope is pointed toward the slit from in front of it, and the star image is kept on the slit by the guiding controls. For objective-prism (or grating) spectra, the dispersion is generally run north and south, and the telescope is allowed to trail slightly in right ascension to widen the spectrum. A filar micrometer eyepiece is of great assistance here to insure uniform widening.

For photographing a comet, a micrometer is also used. The motion of the comet is precomputed (from its ephemeris), the micrometer is moved every little while to follow that motion, and the guide star is then brought up to the intersection again. If you are doing this, make sure that you move the micrometer in the right direction. Solutions to other special problems, such as photographing asteroids and planets, will suggest themselves as experience is gained.

It pays to use all the workable mechanical conveniences you can think up for making guiding easier. Diagonal eyepieces for work at the zenith, flexible cable extensions to the slow-motion screws, chairs of adjustable height, are some of the aids one might adopt. Wearing warm clothes and footgear is to my mind especially important. The more comfortable the observer (so long as he does not fall asleep!), the better the plates, and the more of them.

Conclusion

The important points to bear in mind for successful celestial photography are:

1. Adjust the crosshairs for removing parallax.
2. Look into the eyepiece frequently.
3. Don't move the slow motions unless you have to.
4. Before you move a slow motion, stop to think about which way it needs to be turned.
5. When you move it, ease the star onto the crosswires, and don't move it past them.
6. Keep your equipment in adjustment, especially polar adjustment.
7. Choose the best guide star you can, and plan out your work in advance.
8. Be comfortable, but don't fall asleep.

Early Chapters in the History of Stellar Evolution

By K. E. Edgeworth

THE BUSINESS of the astronomer is not unlike that of the detective: he observes, and he then makes deductions from his observations. But he goes further; from what he observes today he tries to draw inferences as to what may have happened in the dim distant past, thousands of millions of years before the present era.

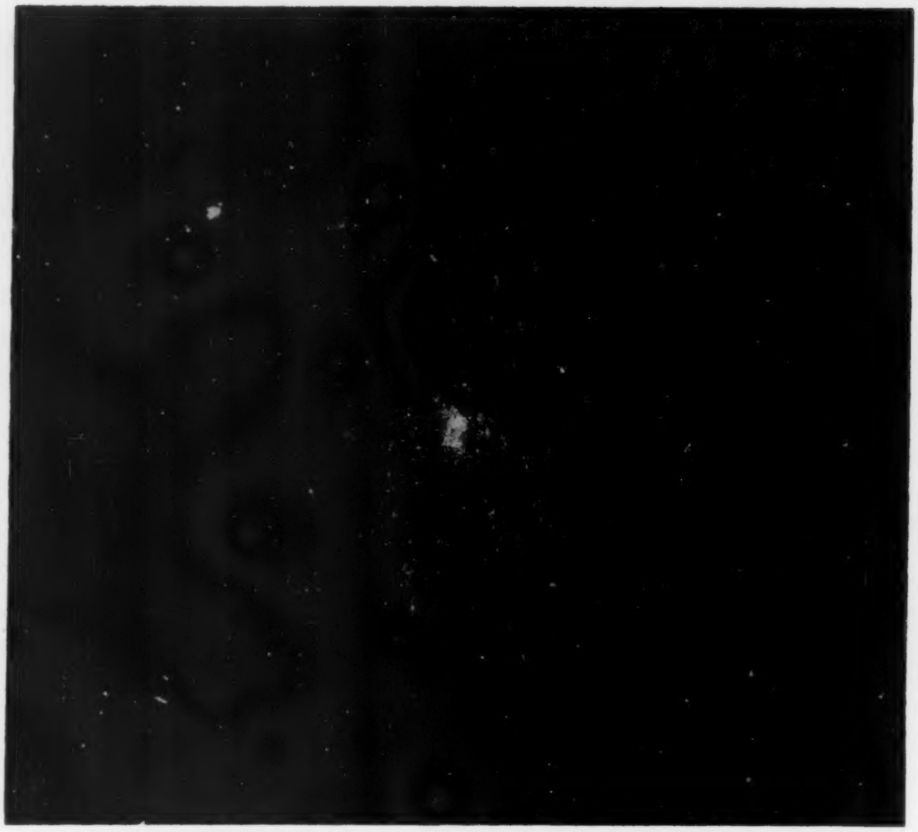
The force of gravity appears to be universal, and, under its influence, the stars are contracting. Reverse the process and we find that, in the past, the stars must have been larger than they are now. Go back far enough, and the material that now composes the stars, planets, and other astronomical bodies must have been scattered more or less uniformly in what we now call interstellar space. The starting point in the story is the assumption that there existed, in the beginning, a vast cloud of extremely tenuous material. The density of this material was of the order of 10^{-24} grams per cubic centimeter, or about one molecule per cubic centimeter.

At the present day the stars are largely composed of hydrogen, and this material is being gradually used up to form helium and other elements. It is clear that the proportion of hydrogen in the original material must have been greater than it is today, and it may be inferred that the original cloud consisted mainly of hydrogen. Interstellar space contains also dust and small solid particles, and it may be assumed that these were also present in small amounts.

The galaxy of stars to which the sun belongs is rotating, and the time taken by the sun to complete one revolution in its orbit about the center of the system is about 200 million years. The shape of the galaxy is that of a disk whose thickness is perhaps one eighth of its diameter. The mass of the material between the boundary surfaces of the disk, in the neighborhood of the sun, is about 1/20 of a gram per square centimeter, or about the same as that of a piece of cardboard, and yet the dimensions of the galaxy are so vast that its total mass is more than that of 100,000 million suns.

The next factor of importance is the angular momentum, the term used by astronomers to describe the quantity of rotation in the system. The principle of the conservation of angular momentum tells us that the angular momentum of a system cannot vary of itself. If a change occurs it must be due to the operation of outside forces. Applying this principle to the galaxy we postulate that, throughout the period of stellar evolution, the total angular momentum has remained substantially unchanged. Moreover, the means available for the transfer of angular momentum from one part of the system to another are very slight, and it may therefore be assumed that the distribution of material in the original disk was substantially the same as it is today. The estimate of 1/20 gram per square centimeter is still applicable.

Our investigation starts then by postulating a rotating disk of hydrogen gas whose mass, diameter, and speed of rotation were not appreciably different from those of the galaxy of today.



The spiral galaxy Messier 33, in Triangulum, photographed by John C. Duncan with the 100-inch telescope at Mount Wilson Observatory on the night of September 2, 1945, when the back-cover picture of this issue was also taken. The exposure was only 14 minutes on Eastman 103aO emulsion, and many details of the nucleus of the galaxy are visible which are overexposed on usual photographs of several hours' duration. The original scale of 16.02 seconds of arc per millimeter (Newtonian focus) is retained in this contact reproduction. Mount Wilson photograph.

The Disk Gets Thinner

Radial contraction of the galactic disk was prevented by rotation, but contraction at right angles to the plane of the disk was still possible. The first chapter in the story of stellar evolution finds the disk getting thinner and thinner. Heat was generated by the contraction, but, owing to the extremely attenuated state of the material, it escaped immediately into space. During this stage the pressure of the gas increased; eventually gravity was balanced by gas pressure, and the process of contraction came to an end. This having happened, the thickness of the disk can be calculated; the formula is

$$t = 2.5 \times 10^{15}\ T/m,$$

where t is the thickness of the disk in centimeters, T is the absolute temperature, and m is the mass of the disk in grams per square centimeter $= 1/20$.

The temperature of a solid particle in empty space is about 2° or 3° absolute, but a gas only radiates on certain special wave lengths and the temperature may be much higher. Hoyle estimates that the temperature of a cloud of hydrogen may be of the order of 10,000° absolute. Dust absorbs heat from the gas and facilitates radiation, so that the temperature of a mixture of gas and dust may be of the order of 100° absolute. For the purpose of the present investigation it will be assumed that the temperature of the cloud was 1,000° absolute, and at this temperature the ratio between the thickness of the disk and its diameter works out at 1/1,200. (The distance of the sun from

the galactic center is taken as 3×10^{22} centimeters.) With the disk at this thickness, the general process of contraction came to an end. So far as the galaxy as a whole was concerned no further contraction was possible.

Gravitational Instability

The general form of the galaxy being established, the next chapter in the history of stellar evolution is concerned with the development of local condensations inside the existing framework.

It can be shown that a large cloud of gas is gravitationally unstable, that is to say, there is a tendency to form local condensations, and the argument is applicable to a rotating cloud such as we are now discussing. It is necessary, however, to trace in greater detail the series of evolutionary processes which begins with a rotating cloud and ends with the formation of the stars.

In seeking to solve this problem there are two clues that serve to guide the astronomer in his search. In the first place, if condensation is to take place at all, the effects of gravity must exceed the effects of gas pressure. This condition leads to the result that the condensations must be of a certain minimum size.

In the second place, the angular momentum of a condensation must remain sensibly constant during the process of contraction, and this condition makes it possible to compare the present speed of rotation of a star with the speed of rotation of the original material.

First Hypothesis: Direct Condensation

In considering the formation of the stars, the first thought that naturally occurs to us is that the stars were formed by a simple process of condensation in the original gas, like droplets in a cloud chamber. We proceed, therefore, to test this hypothesis.

The formula for the minimum mass of a condensation is

$$M/S = 3 \times 10^{-3}\ T^2/m,$$

where M is the mass of the condensation and S is the mass of the sun. Putting $T = 1{,}000^\circ$ and $m = 1/20$, we find that $M/S = 6 \times 10^4$; thus, the minimum mass of a condensation was equivalent to about 60,000 suns. This result is obviously much too large, and our hypothesis must therefore be viewed with grave misgiving.

We now turn to the question of rotation. With a solid rotating disk, every part rotates with the same angular velocity as the whole, and the angular momentum can be calculated accordingly. With a disk of separate particles, each particle moving in its own orbit, the angular velocity decreases as we proceed outwards from the center, and the local angular momentum of a small part of the disk about its own center is less than if the disk were solid, but it is of the same order of magnitude.

Estimating the angular velocity of the original material in this way, and comparing it with the angular momentum of the solar system at the present day, we find that the original angular momentum was some 30 times greater than it should be, and more than 1,000 times greater than that of the sun alone. This is a second serious objection to our hypothesis.

Taking the two objections together, our first hypothesis must be dismissed as untenable.

Second Hypothesis: Successive Condensations

The next thing to do is to explore the possibility that the difficulties encountered in connection with our first hypothesis might be overcome by postulating that the process of condensation took place in successive stages.

Our first trouble was that the condensations which would be formed in the galactic disk would be much larger than the actual stars. This difficulty may be removed if we assume that the first stage was the formation of what may be called subgalaxies, each having a mass of about 100,000 suns. It may then be supposed that the subgalaxies condensed in turn, following much the same course as the galaxy itself, that is to say, each subgalaxy contracted upon itself and assumed the form of a thin disk; the disk became gravitationally unstable; and finally broke up into a number of condensations of stellar proportions.

This hypothesis seems to be dynamically feasible and removes the first difficulty. It does not, however, remove the second objection, for it can be shown that the secondary condensations have the same endowment of angular momentum as before. To overcome this difficulty, further assumption is necessary.

When a rotating mass contracts, there are two factors to be considered in addition to gravity, namely, rotation and gas pressure. In the case of the galaxy, the effects of gas pressure are small and rotation is of primary importance. As for the sun, at the present time, rotation is slow and gas pressure is the chief factor to be considered. In the former case the system assumes the form of a thin disk, and in the latter the shape is a spheroid with only slight flattening at the poles.

In the case we are now discussing, the problem is more complex, since both gas pressure and rotation have to be taken into account. Some very elaborate and elegant mathematical analysis has been applied to the investigation of this problem without arriving at any very satisfactory result. It seems to be generally agreed, however, that a rotating mass such as we have assumed would probably split into two parts and would form a binary system. If that happens, the greater part of the angular momentum would be associated with the orbital velocity of the two parts, and the angular momenta of the individual components due to their rotation would be comparatively small.

Theoretically, the hypothesis that the original cloud of material broke up and condensed to form subgalaxies, that the subgalaxies broke up again to form rotating bodies of stellar mass, and that these bodies split in two to form binary stars, appears to be workable.

It must be remarked, however, that the intermediate structures which are postulated in this theory are of a very permanent character, so that they would be expected to be very much in evidence at the present time. In other words, we should expect to find the stars generally arranged in clusters, and we should further expect to find that all stars were binary stars of fairly uniform pattern. Unfortunately this conclusion does not square with the facts. Clusters are not uncommon, but they do not embrace any large proportion of the stars, and binary systems are common, but they are not universal and they certainly do not conform to any rigid pattern.

Since the results of the hypothesis are not in agreement with observation, it must be inferred that the suggested theory is not the chief process that has been responsible for the evolution of the stars. Insofar as this process may have played a part in stellar evolution, it could only have been a minor part, and the main stream of stellar evolution must have followed some other course.

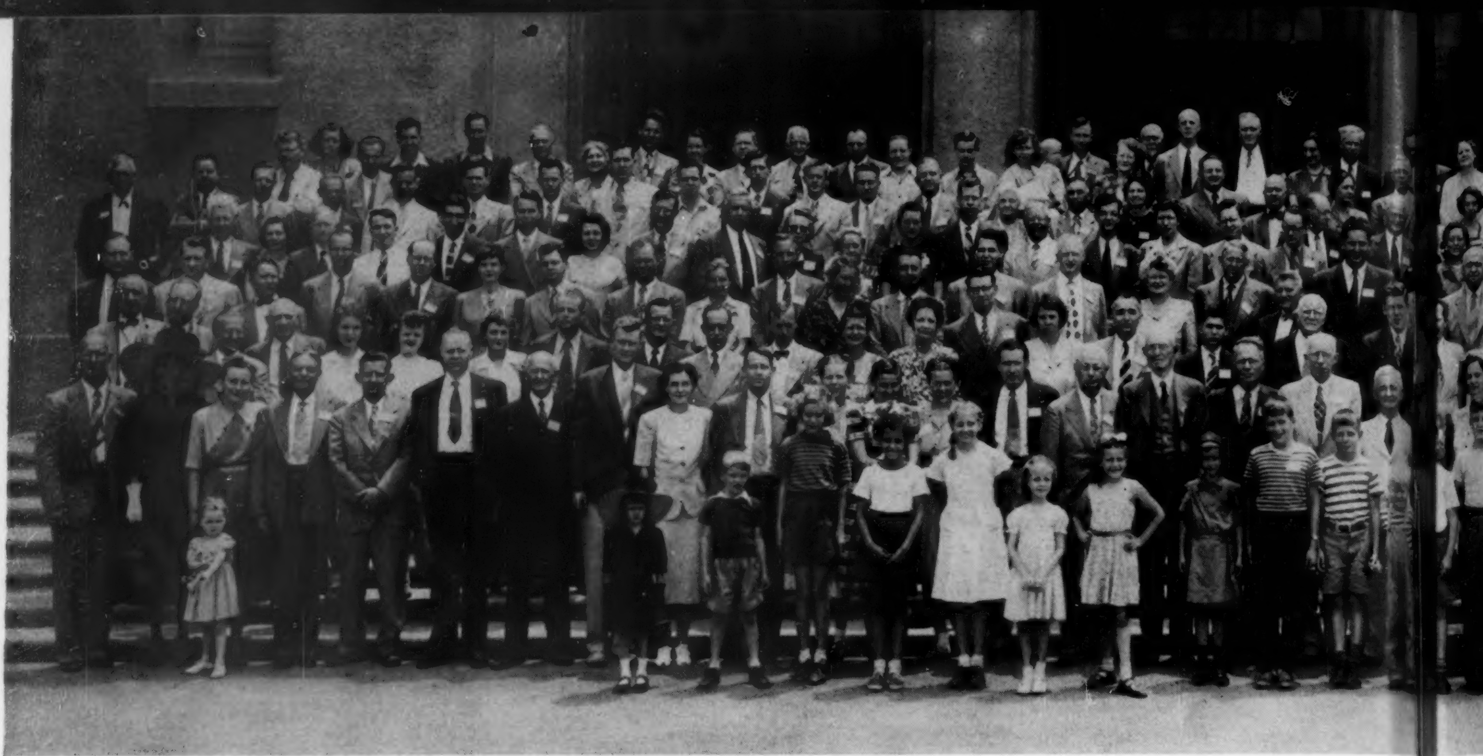
(To be concluded)

TWO NOVAE AND A SUPERNOVA

(Continued from page 242)

Anne B. Underhill, showed strong hydrogen emission lines and other fainter emission features typical of a nova about 2½ to three magnitudes below maximum light. The star's visual magnitude was then about 11.

Via the International Astronomical Union on June 3rd, a day after the discovery of Nova Cygni, came information from Moscow on Nova Serpentis 1948, discovered when of the 9th magnitude. A spectrum in the photographic region was obtained by Dr. W. P. Bidelman on June 9th with the 40-inch Yerkes refractor. It was an apparently normal nebular spectrum characteristic of a typical nova some four to five magnitudes below maximum light. The visual magnitude was estimated to be between 9.0 and 9.5, indicating little recent change in brightness. An accurate position was obtained by Dr. G. Van Biesbroeck on a plate taken June 23rd: (1950) $15^h\ 43^m.3$, $+14^\circ\ 31'.9$. The nova can be identified on the AAVSO "b" chart of R Serpentis: 26 millimeters west and 13 millimeters north of Upsilon Serpentis.



Members and guests at the joint meeting of the American Astronomical Society and the Astronomical Society of the Pacific ornia

GATHERINGS OF T

WITHIN ONE WEEK at the end of June and beginning of July, two gatherings of astronomically minded persons were held in this country which gave evidence of an ever-growing interest in astronomy among both scientists and laymen. On the West Coast the American Astronomical Society met jointly with the Astronomical Society of the Pacific, and at Milwaukee the national convention of the Astronomical League was held, the Milwaukee Astronomical Society acting as host.

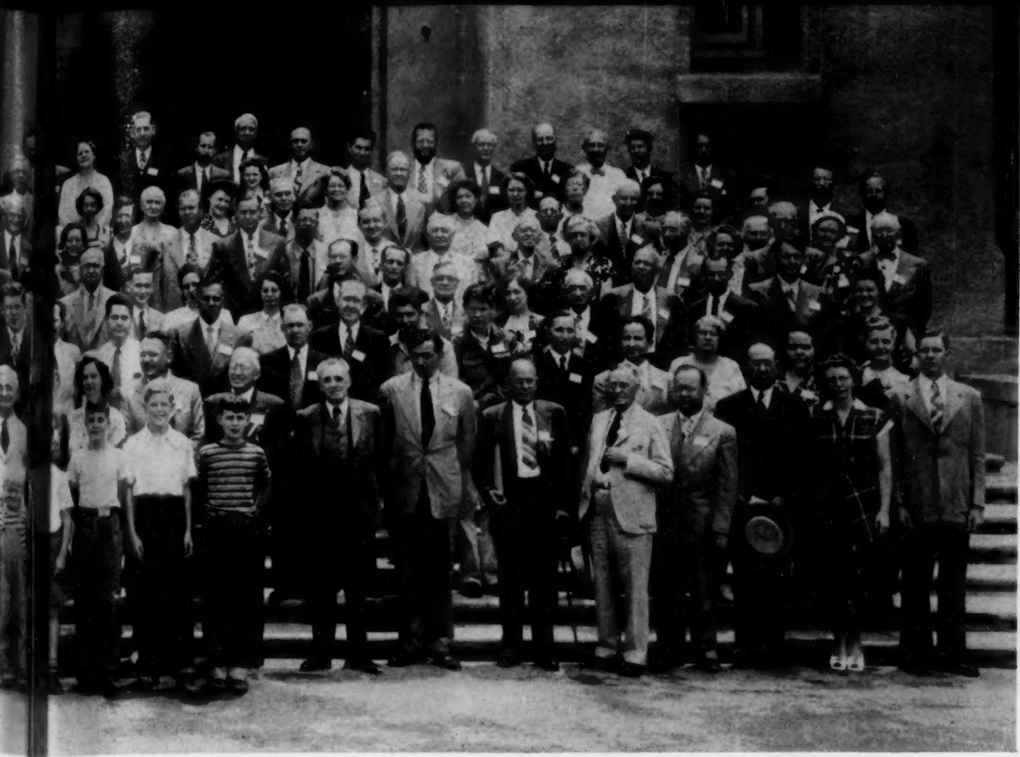
Headquarters for the professional sessions were at the California Institute of Technology in Pasadena. There some 400 persons registered to attend sessions at which about 64 papers were scheduled. There they visited the optical shop in which the 200-inch mirror was processed, viewed the famous Porter drawings, and watched the operation of the 1/10 scale model of the 200-inch which is housed on the roof of the astrophysics building.

The afternoon and evening of Tuesday, June 29th, were spent on Mount Wilson, where an unusually warm day caused many astronomers to become Aquarians for their automobiles on the way up. A colored sound motion picture by Edison R. Hoge was featured during the dinner hour — for 45 minutes it related the fascinating story of the conception and construction of the giant eye on Palomar Mountain. It is expected that this film will eventually be made available for educational purposes. That evening, the 100-inch telescope was host to hundreds, presenting a large and interesting image of Saturn at the coude focus.

Looking back at the history of some of our largest observatories, one wonders if even the 200-inch is certainly immune to the encroachments of civilization, which in the case of the 100-inch have now become so serious as to be detrimental to its continued optimum performance. Nevertheless, this and other Mount Wilson instruments will help make astronomical progress possible in observation and research for many decades in the future.

A report of considerable significance to the future of astronomical research was given at the dinner on Wednesday evening, in the Caltech Athenaeum, by Dr. Otto Struve, president of the AAS. He is chairman of the committee on astronomy advisory to the Office of Naval Research (see *Sky and Telescope*, April, 1948, page 146), and the following also

Delegates and guests at the second national ventio



ific ornia Institute of Technology, June 28-July 1, 1948. Photo by J. Allen Hawkins.

THE CLAN

served: Bart J. Bok, vice-chairman; I. S. Bowen, Dirk Brouwer, C. D. Shane, Lyman Spitzer, Jr., A. E. Whitford.

In accordance with the committee's recommendations on applications received, the ONR was prepared to distribute approximately $50,000 in support of some 20 projects in basic astronomical research at 17 different institutions, and involving the work of between 20 and 30 astronomers.

The final list of recommendations was drawn up solely upon considerations of scientific merit, ability and experience of the applicant, the degree of encouragement the project would give to smaller observatories and departments, the extent to which the project might assist in the training of students, and a few miscellaneous considerations. The committee believes, Dr. Struve reported, that by assisting the ONR in this activity it has helped to funnel important aid to those astronomers and institutions who were least likely to benefit from other government contracts or whose work was in serious danger of being slowly starved through the lack of adequate support.

Dr. Struve went on to list the projects: several dealing with specific problems of photoelectric photometry, including one on the photoelectric scanning of high-dispersion stellar spectra; the computation of orbits of comets, minor planets, and distant satellites; the observation of faint minor planets; the spectroscopic features of white dwarfs; the light curves and absolute luminosities of variable stars; the application of punch-card equipment to astronomical problems; the computation of the characteristics of eclipsing variable stars; the determination of spectroscopic distances of faint stars of type *B*; the use of obsidian as a material for astronomical mirrors; the computation of transition probabilities of astrophysically important atoms; the study of apsidal motions of close binaries; the measurement of the helium content and radioactivity of meteorites; problems of the spectral classification of stars; the study of spectrum variables.

Professional and amateur astronomers are alike concerned with the future of Meteor Crater in Arizona, the largest authenticated earthly scar caused by a meteorite. In discussions at Pasadena and Milwaukee, the need for action was stressed by those interested in the preservation of the scenic and scientific values at Meteor Crater. At present, such activities as silica mining on its rim and the uncontrolled removal of meteoritic fragments by unauthorized persons

(Continued on page 259)

l convention of the Astronomical League, Concordia College, Milwaukee, Wis., July 3-5, 1948.

BOOKS AND THE SKY

PICTORIAL ASTRONOMY

Dinsmore Alter and **Clarence H. Cleminshaw.** Griffith Observatory, Los Angeles, 1948. 288 pages. $3.15.

PICTORIAL ASTRONOMY was written primarily for the layman, although the authors mention that it is also suitable for a short cultural course in astronomy or for use in high schools. These purposes it should serve admirably. It is attractively arranged and, as the title suggests, copiously illustrated with photographs and diagrams. One should not be misled, however, to think that the text is scanty or unimportant. It has been excellently written with a view to making the subject readily understood. Veteran astronomers and teachers will welcome this new presentation and the illustrations, many of which are large enough to display before small classes.

One feature of special interest to the layman, and often treated rather scantily in other texts, is abundant historical information. Hardly a subject is introduced without an account of the early observations and the theories proposed to explain them. Especially noteworthy is the discussion of sunspots and their relation to other phenomena.

The book might be introduced as providing answers to many of the questions often asked by laymen, students, and children: How does the moon cause tides? Why does Phobos revolve around Mars faster than the planet rotates? Why do we have twilight? What astronomer advised Pope Gregory in the matter of calendar reform? How did the tropics of Cancer and Capricorn get their names? The authors, who have had ample experience during their years of operating the Griffith Planetarium, seem to anticipate the questions of the layman and to provide lucid explanations. They are especially to be commended for stating fundamental principles of science in simple terms.

The book begins with several chapters about the sun, because, as emphasized throughout, it is a typical star and just about average among the family of stars.

The chapters about the moon have been especially planned for those who would observe it carefully either with or without optical aid. There is a series of nine pictures of the moon at different phases, as seen erect through binoculars, with a description of the most prominent features. Several large Mount Wilson photographs are reproduced, and for those who wish to make telescopic observations Duell's map of lunar features is included. There is an account of Aristarchus' measurements of the size and distance of the moon.

The complicated subject of eclipses is discussed with remarkable clarity. The chapter on foretelling eclipses by simple methods is an innovation which greatly aids in understanding how the ancients predicted eclipses.

The study of constellations and bright stars, which is postponed until Chapter 38, provides an excellent guide for those just learning to recognize the configurations. The shapes of constellations are described in common terms: Bootes looks like an ice-cream cone; Cepheus looks like a house with a high, steep roof. In addition to the usual maps, five diagrams with a few heavy connecting guide lines, arcs, and triangles, make the transfer from one constellation to another easy.

The whole subject of astronomy is quite adequately covered with up-to-date information. The many tables set forth a wealth of information in a brief, handy form. If an index had been provided the book would be much more convenient as a ready reference. Nevertheless, **Pictorial Astronomy** should serve as a welcome and popular addition to many libraries on astronomy.

RUTH HAYNER
Floral Park, N. Y.

COLLEGE PHYSICS

Francis Weston Sears and **Mark W. Zemansky.** Addison-Wesley Press, Inc., Cambridge, Mass., 1948. 848 pages, tables and index. $6.00.

OF ALL THE SCIENCES, physics is more basic to astronomy than any other, especially as the modern phases of physics include so much of the chemistry of the interior of the atom. A reader of astronomical literature who has a firm training in the branches of physics known as mechanics, heat, sound, electricity and magnetism, optics, and atomic physics (the principal divisions of the book under review) need never be at a loss to follow

the details of a technical discussion in celestial mechanics or astrophysics.

Few amateur astronomers, however, may have had recent training in these subjects, and those who took their science seriously years ago in high school or college will find their reference texts notoriously out of date and deficient in many phases of modern physics. The addition to one's library for current study or reference of such a volume as **College Physics** should pay big dividends in appreciation of astronomy. This book is compiled by two expert teachers, Dr. Sears a professor of physics at Massachusetts Institute of Technology, and Dr. Zemansky an associate professor of physics at the College of the City of New York. Both of these schools are noted for their attention to the needs of the undergraduate student, and for their realization of the importance of a knowledge of basic scientific principles by all college students, whether majoring in the arts or the sciences.

As stated in the preface, this text consists exclusively of material suitable for first-year college students whose mathematical preparation goes no further than algebra and the elements of trigonometry. Few amateur astronomers, then, should have difficulty in availing themselves of the facts presented so excellently by Sears and Zemansky.

Of particular interest to astronomically minded persons are the chapters on motion, Newton's second law, and circular motion in the first part of the book; and Chapters 39 through 47, on light, optics, color, and polarization.

The book is characterized by the adequacy of its problems at the end of each appropriate chapter (with answers in the back of the book), by a good index, and by the high quality of manufacture, with numerous halftones and several color plates supplementing the well-executed line drawings.

Here is an example of the straightforward presentation maintained by the authors throughout the book. Accompanying a 500x enlargement of a section of the human retina, there is this description:

"A large part of the inner surface of the eye is covered with a delicate film of nerve fibers, **R**, called the **retina.** A cross section of the retina is shown in Fig. 43-2. Nerve fibers branching out from the **optic nerve O** terminate in minute structures called rods and cones. The rods and cones, together with a bluish liquid called the visual purple which circulates among them, receive the optical image and transmit it along the optic nerve to the brain. There is a slight depression in the retina at **Y** called the yellow spot or macula. At its centre is a minute region, about 0.25 mm in diameter, called the **fovea centralis,** which contains cones exclusively. Vision is much more acute at the fovea than at other portions of the retina, and the muscles controlling the eye always rotate the eyeball until the image of the object toward which attention is directed falls on the fovea. The outer portion of the retina merely serves to give a general picture off the field of view. The fovea is so small that motion of the eye is necessary to focus distinctly two points as close together as the dots in a colon (:)."

C. A. F.

GLEANINGS FOR A. T. M.s

THE COMPOUND REFLECTING TELESCOPE — IV

By Allyn J. Thompson

If made following directions to be given here, the spherical secondary may be within required tolerances, because of its short radius.* It can be tested under monochromatic light against the polished surface of its concave tool, the latter having first been checked by the Foucault test. In this interference test it is not essential that straight bands be obtained. Curved bands or rings denote convexity with respect to the "fit" of the adjacent surfaces, but so long as there is no deviation in the curvature of the bands, or in the progressively varying separation of the rings, the convex secondary will in truth also be part of a sphere. The desired precision of figure is about ⅛ of a wave length.

As already mentioned, Fig. 15 shows the method of testing the concave ellipsoidal secondary of a Gregorian telescope. A light source is at **L**, the pinhole at **f**, and the knife-edge at **f'**. A very small right-angle prism, **P**, has black paint on its square surface facing the primary. This paint is punctured with a needle point, thus making the pinhole upon which light is concentrated by the condensing lens **C**. To avoid some of the obstruction by the prism, a small Lucite tube with a right-angle bend can "pipe" the light into position, or a shiny steel ball or globule of mercury can be made to reflect light from a source to the side of the optical train so positioned as to give a bright image.

When the approximately spherical concave secondary is tested in this manner, its apparent figure is that of an oblate spheroid (**a** or **a'**, Fig. 13). Figuring consists of deepening the small mirror's central zones, and is persisted in until, when the knife-edge is cut in at **f'**, the mirror darkens evenly just as does a spherical mirror tested at its center of curvature.

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*ED. NOTE: Not all mirror makers will agree with Mr. Thompson that the most careful polishing of even a small-diameter, short-radius mirror will necessarily produce a surface which is spherical to within ⅛ wave length. We certainly would not want to suggest that testing may be unnecessary. To test by interference against the tool may require figuring and polishing both the concave and convex surfaces on appropriate laps and checking them by interference. If they fit in all positions and locations, they must be spherical (or flat).

Alternatives are to mount the convex secondary in front of a concave mirror of known figure, interpreting the figure of the secondary from this knowledge of the primary figure. Discussions are given in this article of the appearance of spherical secondaries against primaries of various figures.

In the case of machine polishing on a spindle, one can expect sphericity within about one wave length. Careful hand work should produce better results, but sphericity of ⅛ wave length without testing is not to be expected by most amateurs.

A spherical secondary for the modified Gregorian will, of course, be tested at its center of curvature. When tried in conjunction with the paraboloidal primary, using parallel light, undercorrection will show up in the image; under the knife-edge the apparent shape of the primary will be like **a** or **a'** in Fig. 13. As already stated, the primary mirror is further deepened until the aberration has been reduced to tolerable limits. The perfectly corrected system was illustrated in Fig. 9.

Star Testing. Where means of testing with an optical flat are not available, the parallel-light test can be made with a knife-edge on the image of a star. A smoothly working focusing control on the eyepiece is absolutely essential for reasonably exact measurement. The practically stationary Polaris is the most convenient subject for the test, although where but one mirror is aluminized, a 2nd-magnitude star will not furnish sufficient light for small telescopes. First bring the star into focus with a low-power eyepiece which is then removed from the adapter. With-

Edited by Earle B. Brown

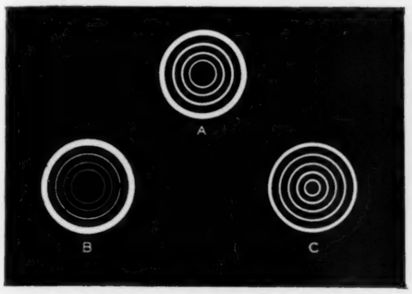


Fig. 17. Extra-focal diffraction ring patterns.

draw your eye several inches, and the star image will be seen apparently in the secondary mirror. When your eye is then brought forward to its former position, the image seems to expand and to fill the mirror with light. With a razor or knife blade held flat against the end of the adapter tube, try now to determine the position of focus as indicated by the direction of shadow approach.

If the knife-edge is located inside of focus, the shadow will appear to move in from the same direction as the knife-edge when it is cut in; if outside of focus, the shadow will appear from the side opposite to the knife-edge and will move opposite to the movement of the knife-edge. At first, focus will probably be found to lie within the adapter tube. By adjusting the focusing mechanism during repeated trials with the knife-edge, the open end of the adapter tube can be located exactly in the focal plane. A little practice may be necessary before the blade movement can be satisfactorily controlled. If screw-threads are used in focusing, aberrations can be measured with sufficient accuracy by counting the number of rotations or fractional rotations made as the knife-edge is tried at the focus of different zones. The apparent shape of the mirror (or secondary) is interpreted just as when using the optical flat, or in testing a concave mirror at its center of curvature. Atmospheric perturbations will sometimes interfere with performance of the test, so the higher the altitude of the star the better. On account of this difficulty, although starlight furnishes an easily procured means of testing, more accurate results can be obtained indoors with a high-quality flat. Some amateurs have successfully employed very distant terrestrial light sources, such as the filament of a street lamp a mile or so away.

The early telescope makers did not use the knife-edge test on the stars, but compared the out-of-focus images seen in a high-power eyepiece — one giving a magnification of about 30 or more per inch of aperture. When the eyepiece is moved a short distance in or out of focus, the star image expands into what at first may appear to be a fuzzy disk, but which, atmospheric conditions permitting, can be resolved into a series of concentric diffraction rings. With a perfect optical system, the expanded diffraction-ring appearances, at equal distances on either side of focus, will be identical. The outer ring appears widest and brightest, and there is a progressive diminution in the luminosity of each inner ring (**A**, Fig. 17).

In the reflector, a dark spot will be seen at the center, the innermost rings being cut out by the secondary obstruction. If the dark spot is larger inside of focus than it is at an equal distance outside of focus, undercorrection is indicated; overcorrection is present if the spot is largest outside of focus. With undercorrection, the ring appearance inside of focus will bear some resemblance to **B**, the inner rings being faint; outside of focus, the rings will appear conspicuously brighter, as at **C**. The reverse of this is found with overcorrection. The reason for the varying distribution of light in the diffraction rings can be gleaned from a study of the ray paths in the undercorrected (**a**) and overcorrected (**b**) telescopes in Fig. 18. In these diagrams, **c** marks the circle of least confusion, or position of best focus, and the vertical lines on either side of **c** identify the extra-focal planes referred to above.

In addition to the two general errors described above, there are a multitude of variations, each accounting for one form or other of surface deformation, and each demanding accurate interpretation if proper corrective action is to be taken. Analyzing some of these confused-looking ring systems, or splotches as they may sometimes appear to be, is not easy, and the knife-edge test at focus, while less sensitive to error, will be more productive of results. Indeed, after a few trials on the diffraction rings, the amateur will

come away with a profound respect for the patience and skill of his elders.

Conclusions. After reviewing the various methods of testing, problems of correction, and performance features, two systems, the Cassegrainian and the Dall-Kirkham, stand out as being the most practical. It can be seen that low amplifications are out of the question in the Gregorian if the secondary mirror is not to be unduly

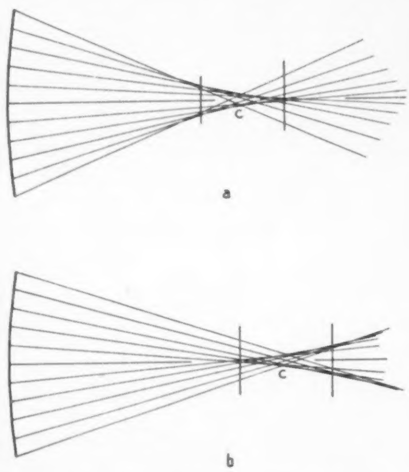


Fig. 18. Undercorrection (a) and overcorrection (b) in the telescope. The circle of least confusion is marked by c. The extra-focal images of Fig. 17 are located in the planes marked on each side of the position of best focus.

large. The erect image offers no inducement to the astronomer, and while its slightly flatter field is a point to be considered if the telescope is to be used photographically, it is hardly decisive. The considerably greater tube length is the most serious objection to the Gregorian. Nevertheless, for the benefit of those amateurs who may be attracted to this telescope, a formula for computing the radius of curvature of its secondary is

$$r = \frac{2p' p}{p' + p}, \tag{3}$$

where **p** is the distance **Fs**, and **p′** equals **fs**, in Fig. 1.

Because of the excessive coma, the spheroblate design is ruled out as being undesirable.

In performance, the Cassegrainian telescope, which must be tested and corrected with parallel light, leaves little to be desired. This is probably the instrument for the skilled and critical amateur to make.

The attractiveness of the Dall-Kirkham telescope lies in the simplicity of production of its secondary, but correction of the primary mirror poses a challenge. Because of the enormous magnification of figuring errors in the primary — equal to the square of the amplifying ratio — undertaking this design becomes a rigorous test of the mirror-maker's skill. The method does, however, dispense in some measure with the need for testing in parallel light, and it offers the less skilled amateur an opportunity to possess a powerful, compact instrument with a minimum of trouble and expense.

(To be continued)

GATHERINGS OF THE CLAN

(Continued from page 253)

from its vicinity threaten irreparable damage to the crater. In recognition of these facts, the Astronomical League and the American Astronomical Society passed similar resolutions expressing their desire to have the Meteor Crater area protected by some form of state or federal control, as are the many parks and monuments in the country.

A first impression at Palomar Mountain was that in the vast spaciousness of the plateau the 200-inch dome seemed not as enormous as expected. Inside, the Hale telescope did not itself seem of extraordinary proportions. But the way in which the observatory housed half a thousand persons without crowding, the ease with which the dome turned while most of them rode along on the inner and outer viewing platforms, and the "long look" upward to the crane in the top of the dome furnished clues to the immensity of this astronomical equipment. The instrument is modernistic in every respect, its smooth-welded mounting blending harmoniously with the simplicity of the huge dome. The same may be said of the extremely compact 48-72-inch Schmidt telescope, for which about a year will be required to install the optical parts.

After Dr. I. S. Bowen, director of Mount Wilson and Palomar Observatories, had given a general welcome, Dr. John A. Anderson described the optics of the telescope, and Bruce Rule explained the many engineering principles and problems involved. In spite of its size and complexity, the world's largest telescope will require in normal operation only the presence of the astronomer and his assistant. Staff astronomers, as for Mount Wilson at present, will reside in or near Pasadena and travel to Palomar Mountain (about 3 1/2 hours driving time) for regular periods of observing. Test photographs are yielding highly satisfying results, but it is not expected that operating perfection will be attained before the end of this year. Much work remains to be done in final adjustments of the mirror-supporting system and in the completion and installation of auxiliary apparatus, such as the secondary mirrors and the coude spectrograph.

The photographic limit of the 100-inch telescope is the 21st magnitude, whereas the 200-inch will reach to stars and galaxies as faint as 22.5. In describing some of the projects definitely scheduled for Mount Palomar, Dr. Walter Baade pointed out that already astronomers are prepared to utilize observations made at the 22.5-magnitude limit of the Hale telescope. Of special importance will be work on the distances, motions, and distribution of the most distant galaxies.

C. A. F.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

Checking the Period of Algol

IT HAS BEEN SUGGESTED that the Algol system consists of three bodies, and that the third body lengthens and shortens the period of the eclipsing pair which produces the variations in the light of this well-known variable. To determine the extent of the changes in period, it is essential to compare the observed times of minima with a carefully prepared table of predicted minima.

The judgment necessary to determine the magnitude of a star whose brightness is constantly changing requires considerable observing experience, yet the period of Algol is such that the minima are spread through the day and night, and the office-working amateur can seldom observe more than one minimum each month. One should plan to work from two hours before minimum until two hours afterward. This observer thinks that the simplest way to determine the time of minimum is to note the times when Algol, while decreasing and increasing, equals in brightness the three comparison stars, of magnitudes 2.91, 2.96, and 3.10, shown in Fig. 1. Averaging the times of equal brightness and taking a mean will determine the time of minimum.

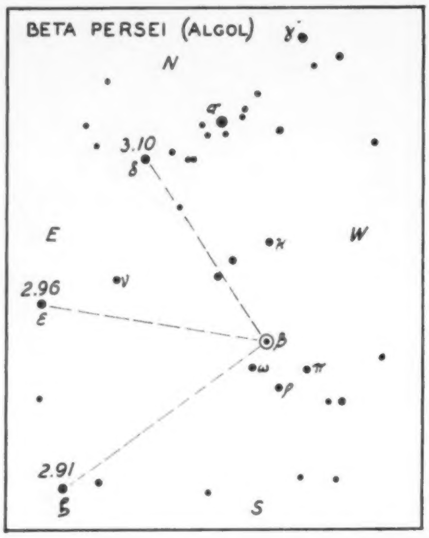


Fig. 1. The comparison stars for Algol minima. Delta, Epsilon, and Zeta Persei are all B-type stars, as is Algol. At minimum, Algol is magnitude 3.5; between eclipses, 2.2.

The first step in a current attempt to set up a table of minima predictions was made late last year when the time of a minimum of Algol was obtained within a fraction of a minute. Visual observations by D. W. Rosebrugh, of Waterbury, Conn., and the writer were combined with data furnished by O. J. Eggen, of Washburn Observatory, who had previously observed an Algol minimum with a photoelectric cell. Thus we established an epoch from which future minima may be estimated.

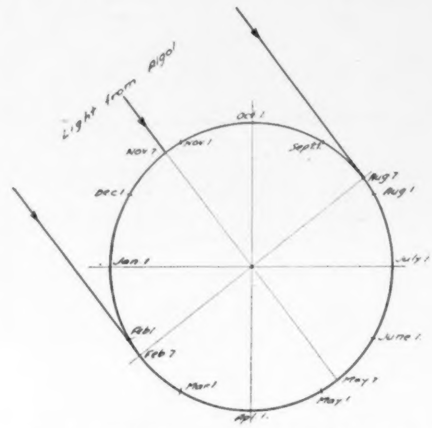


Fig. 2. Positions of the earth in its orbit as related to the light from Algol.

The correction of the apparent time of minimum to compensate for the position of the earth in its orbit at the time of observation requires some study. The radius of the earth's orbit is 93,005,000 miles, from which it may be calculated that the earth travels 11,200,000 miles in seven days. Light goes at a speed of 186,271 miles each second, or 11,176,260 miles in a minute. The estimated period of Algol is 2.867318 days. This means that if we correct the time of minimum by one minute we should not make this correction more frequently than once in three periods of Algol.

This star crosses the meridian at local midnight on or about November 7th, and at noon on or about May 7th. As shown in Fig. 2 the earth is at these times nearest to and farthest from the star, and minimum times will be observed earlier than normal in November, and later than usual in May. Were Algol in the plane of the ecliptic the resulting equation of light

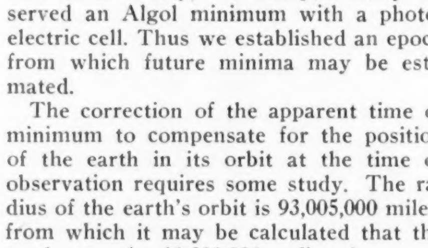
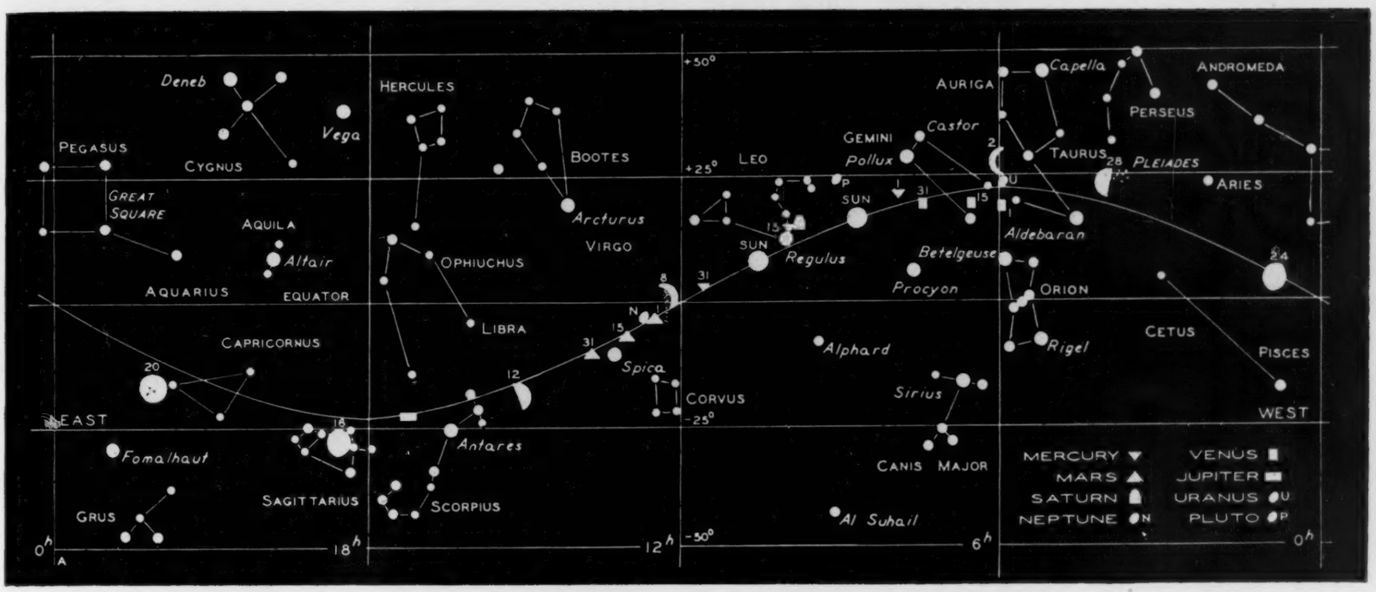


Fig. 3. Algol's position above the plane of the ecliptic, and the resulting maximum correction to the light equation.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury is too near the sun to be seen. Superior conjunction occurs on the 11th, the planet entering the evening sky.

Venus, the brilliant morning star, is now approaching its greatest western elongation in early September. In a telescope it is a crescent 38" in diameter and 30 per cent illuminated. By the 30th, Venus will be below Castor and Pollux and rising 3½ hours before the sun.

Mars sets about two hours after the sun. On the 22nd, it passes 2° north of Spica, and it is somewhat fainter than that star.

Jupiter, magnitude −2.0, is located about 12° east of Antares. Retrograde motion ceases on August 16th, the planet moving eastward again.

Saturn is in conjunction with the sun on August 19th, invisible the entire month.

Uranus is close to a 4th-magnitude star, 1 Geminorum, passing 20′ north of it late in August.

Neptune is too near the sun to be favorably observed this month. E. O.

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would be 8.3 minutes, plus or minus, at these times.

Algol, however, is not on the ecliptic, but about 23 degrees north of it (see Fig. 3). Therefore, 8.3 minutes should be multiplied by 0.92, the cosine of 23°, to give us approximately 7.6 minutes maximum correction.

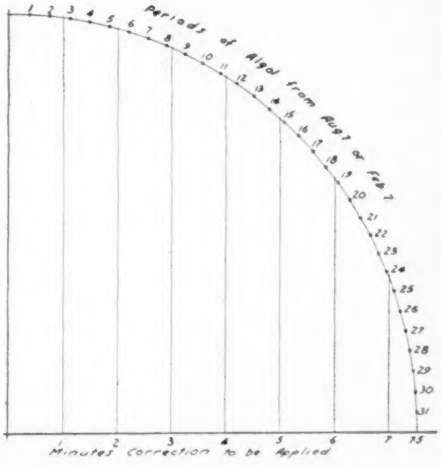


Fig. 4. A miniature of the chart used by Mr. Seely to determine the light correction for minima of Algol.

The length of the period will decrease from August 7th to November 7th, and the rate of decrease will be lessening. From November 7th to February 7th, the period lengthens at an increasing rate. What takes place in the other two quarters is obvious. To calculate the times of minimum for intermediate periods means long and tedious work, but graphically they can be determined with little trouble, as seen in Fig. 4.

From the intersection of two lines at right angles draw an arc of 90 degrees with a radius of 7½ inches (7.6 inches may be used if desired). Commencing at the original vertical line draw vertical lines one inch apart cutting the arc. By means of a pair of dividers mark off 32 equal divisions of the arc and number these points 0 to 32 (vertical to horizontal). The divisions represent the periods of Algol in three months, and the verticals form a light-correction scale for the times of minima. The table shows the periods to be corrected, and the minute corrections estimated to fractions of a day.

To obtain the dates and times of minima from August to November add values in column **B** to the Julian date and decimal (6 places) of the minimum nearest August 7th. To determine the time near February 7th, add the time of 64 periods (183.508352 days) to the August date and from this value subtract the values in column **A.** Reduce the Julian dates to standard time and interpolate the times of the intervening minima.

For example, a minimum of Algol is predicted for JD 2432772.954861, which corresponds to August 9, 1948, at 05:55 EST. Six periods later require the addition of 17.202386 days, or JD 2432790.157247. This corresponds to August 26th, at 10:46.4 EST. The schedule below shows the predicted times for current months, given with the hope that some of these minima will be accurately observed and the times reported.

ROY A. SEELY
969 Park Ave.
New York 28, N. Y.

Number of Periods	*Total Days*	*Correction Minutes*	*Correction in Days*	*A—Total Days Plus Correction*	*B—Total Days Minus Correction*
3	8.601954	1.1	.000763	8.602717	8.601191
6	17.203908	2.2	.001522	17.205430	17.202386
9	25.805862	3.2	.002222	25.808084	25.803640
12	34.407816	4.2	.002916	34.410732	34.404900
15	43.009770	5.1	.003541	43.013311	43.006229
19	54.479042	6.0	.004166	54.483208	54.474876
25	71.682950	7.1	.004930	71.687880	71.678020
32	91.754176	7.5	.005208	91.759384	91.748968

MINIMA OF ALGOL

(These times are GCT.)

August 3, 17:17.7; 6, 14:06.3; 9, 10:54.9; 12, 7:43.5; 15, 4:32.1; 18, 1:20.7; 20, 22:09.3; 23, 18:57.8; 26, 15:46.4; 29, 12:35.0. September 1, 9:23.6; 4, 6:12.2; 7, 3:00.8; 9, 23:49.4; 12, 20:38.1; 15, 17:26.8; 18, 14:15.4; 21, 11:04.0; 24, 7:52.6; 27, 4:41.2; 30, 1:29.8. October 2, 22:18.4.

These predictions are based on observations made in 1947, and are for times about three minutes earlier than those given in the **Observer's Handbook** of the Royal Astronomical Society of Canada.

OCCULTATION PREDICTIONS

August 12-13 **41 G Scorpii** 6.4, 16:10.6 —24-17.4, 8, Im: **A** 1:20.3 —1.8 —1.1 109; **B** 1:15.4 —1.7 —1.0 106; **C** 1:15.7 —2.0 —1.1 115; **D** 1:06.6 —1.9 —0.9 111; **E** 0:47.7 —1.8 —0.7 125; **F** 0:48.3 —1.2 —1.9 155.

14-15 **38 B Sagittarii** 4.7, 18:04.8 —28-27.9, 10, Im: **A** 3:16.1 —2.4 —2.2 139; **B** 3:07.8 —2.1 —1.6 132; **C** 3:12.3 —2.7 —2.4 143; **D** 2:58.0 —2.2 —1.4 131; **E** 2:36.9 —2.1 —1.0 136; **F** 2:46.2 ... ... 174. Em: **A** 4:04.6 —0.4 +0.4 212; **C** 3:59.8 —0.6 +0.9 210; **E** 3:42.1 —1.8 +0.5 228; **F** 3:06.3 ... ... 197.

16-17 **A Sagittarii** 5.0, 19:55.8 —26-20.3, 12, Im: **A** 4:16.9 —0.3 +1.7 12; **B** 4:23.5 ... ... 0; **C** 4:08.1 —0.6 +2.1 13; **F** 3:09.0 —2.6 +3.9 19; **H** 2:31.6 —2.5 +3.9 24.

20-21 **Psi² Aquarii** 4.6, 23:15.2 —9-28.0, 16, Em: **C** 10:55.7 —0.2 +0.4 220; **E** 10:49.0 —0.8 —0.2 240; **F** 10:39.1 —0.8 +1.0 219; **G** 10:03.2 +0.3 +2.3 177; **H** 9:54.3 —4.1 —1.6 287; **I** 9:59.5 —0.4 +1.6 193.

25-26 **124 B Arietis** 6.4, 2:50.3 +16-16.3, 21, Em: **A** 5:58.5 —0.3 +2.4 214; **B** 6:04.9 —0.4 +2.2 221; **C** 5:49.1 —0.2 +2.3 215; **D** 5:58.7 —0.3 +2.2 226; **E** 5:48.6 —0.2 +1.9 235; **G** 6:05.4 0.0 +1.6 266.

26-27 **22 H¹ Tauri** 6.0, 3:41.4 +20-45.9, 22, Em: **A** 6:16.6 —0.3 +2.1 230; **B** 6:22.2 —0.4 +2.0 237; **C** 6:08.2 —0.2 +2.0 231; **D** 6:16.5 —0.3 +1.9 241; **E** 6:07.9 —0.1 +1.6 250; **G** 6:22.8 +0.1 +1.3 285.

28-29 **BD +26° 884** 6.5, 5:35.7 +26-35.4, 24, Em: **A** 6:19.2 —0.4 +0.8 291; **B** 6:21.0 —0.5 +0.7 299; **C** 6:14.8 —0.2 +0.7 290; **D** 6:17.2 —0.4 +0.5 304.

For selected occultations visible at standard stations in the United States and Canada under fairly favorable conditions, these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
I +123°.1, +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

PERSEID METEORS

The Perseid meteor shower, having begun the latter part of July, comes to maximum on August 10-13. This year, first quarter occurs on August 11th, so observations made after midnight near maximum will not be hindered by moonlight. Hourly rates of the Perseids will increase steadily from August 1st until maximum, when from 50 to 70 meteors per hour may be expected. Although the radiant, located a few degrees north of Gamma Persei, is always above the horizon for most northern observers, maximum rates will be obtained from midnight until 3 a.m. local time.

Swift, bright meteors are characteristic of the Perseid shower. One or more fireballs ought to be seen during several hours of observing near maximum. Some meteors will have trains enduring from one to five seconds. About 85 per cent of all meteors observed on August 10-13 will be Perseids.

E. O.

VARIABLE STAR MAXIMA

August 6, S Coronae Borealis, 7.5, 151731; 6, S Herculis, 7.6, 164715; 17, U Herculis, 7.6, 162119; 18, R Ophiuchi, 7.6, 170**215**; 21, R Centauri, 5.9, 140**959**; 22, R Reticuli, 7.7, 043**263**.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

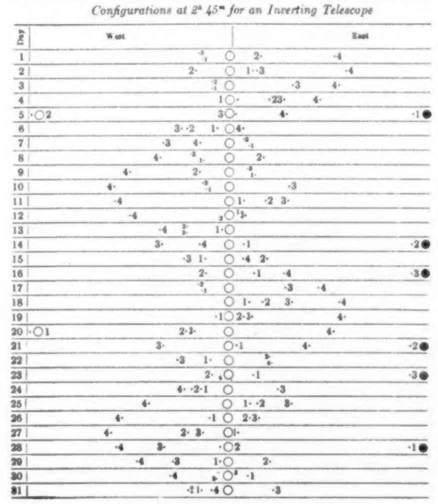
PHASES OF THE MOON

New moon	August 5,	4:13
First quarter	August 11,	19:40
Full moon	August 19,	17:32
Last quarter	August 27,	18:46
New moon	September 3,	11:21

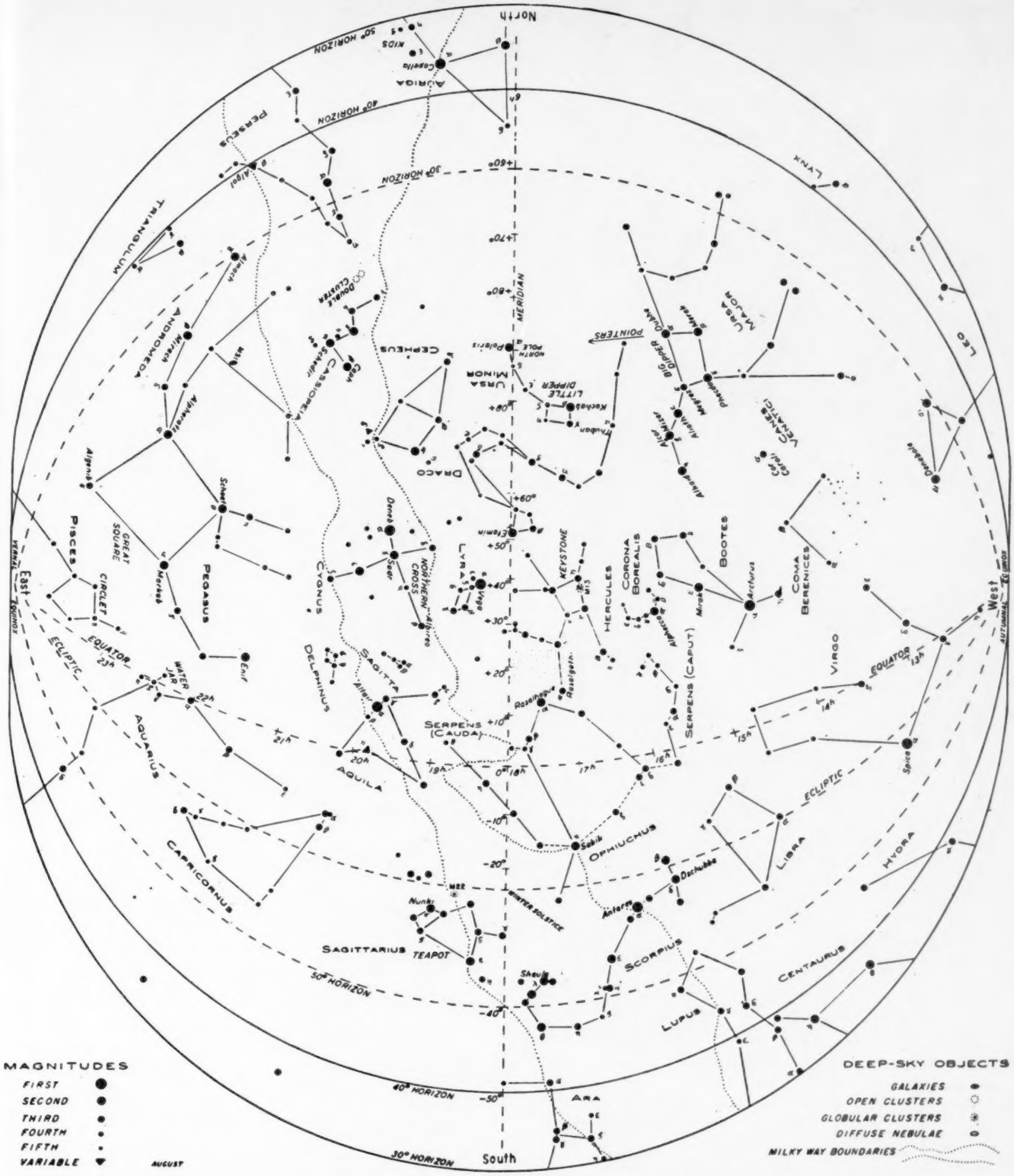
JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**

Configurations at 2h 45m for an Inverting Telescope



CORRECTION: Raymond C. Stevenson, of Flint, Mich., points out that the statement last month on page 236 that Europa is eclipsed from 1:50 on July 28-29, should have read, "Europa is in transit from 23:16 to 1:50."



DEEP-SKY WONDERS

CLUSTER-RICH AREAS of the Milky Way drop lower and lower along the western horizon as the evening wears late in August, and the amateur should observe these southern galactic clusters before the relatively barren areas of fall completely dominate the sky. The H numbers are from a list in Shapley's **Star Clusters,** Appendix B (1930), of clusters which had not previously been catalogued.

H15, $17^h\ 25^m.8$, $-29°\ 23'.7$, 10′ in diameter, 15 stars, 9th magnitude, 0.5 kiloparsecs distant. **H16,** $17^h\ 27^m.9$, $-36°\ 43'.7$, 15′, 20 stars, 8.5, 0.5 kpc. **NGC 6383,** $17^h\ 31^m.4$, $-32°\ 27'.8$, 6′, 12 stars, 9.5, 0.7 kpc. **NGC 6400,** $17^h\ 36^m$, $-36°\ 50'.8$, 6′, 25 stars, 9.0, 0.5 kpc. **NGC 6404,** $17^h\ 35^m.3$, $-33°\ 8'$, 3′, 20 stars, 10, over 1 kpc.

NGC 6405, M6, $17^h\ 35^m.7$, $-32°\ 6'.7$, 25′, 50 stars, 8.3, 0.4 kpc. **H17,** $17^h\ 35'$, $-39°\ 59'$, 10′, 20 stars, 9.6, 0.8 kpc. **NGC 6416,** $17^h\ 40^m$, $-32°\ 15'.8$, 20′, 25 stars, 8.3, 0.4 kpc.

A very loose cluster, hard to distinguish, is **I4665,** $17^h\ 43^m.6$, $+5°\ 43'$, 60′, 13 stars, 7, 0.2 kpc.

WALTER SCOTT HOUSTON

STARS FOR AUGUST

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired. Our regular charts for observers in the Southern Hemisphere appear in alternate issues.